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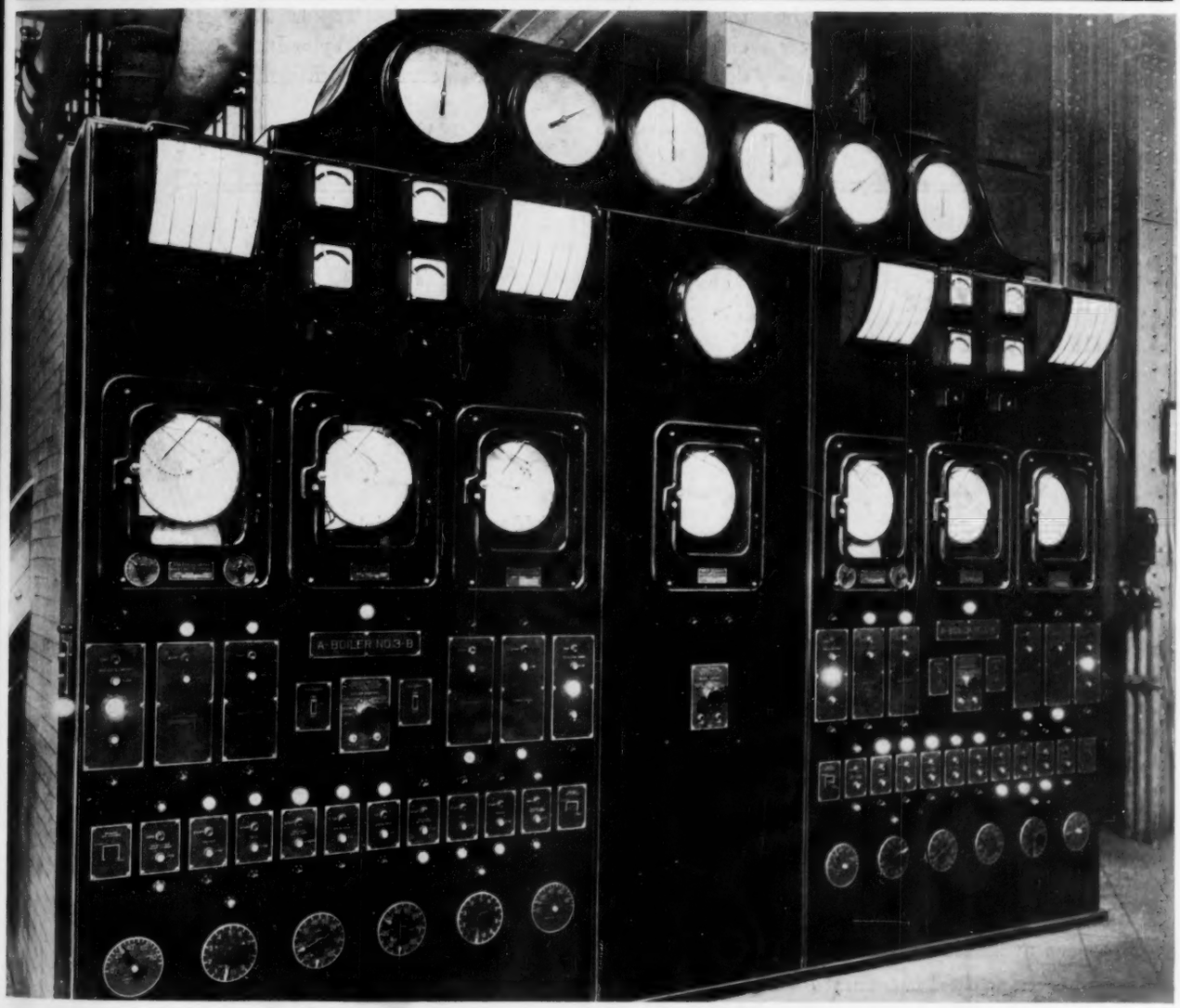
INSTRUMENTS

THE MAGAZINE OF MEASUREMENT AND CONTROL

VOLUME 6 DECEMBER, 1933 NUMBER 12



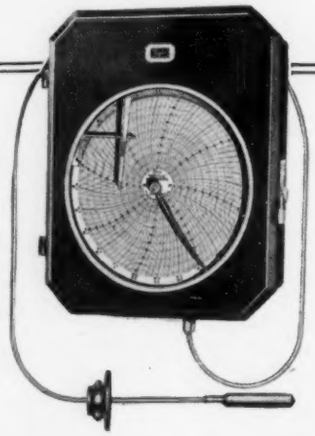
INDIVIDUAL BOILER PANELS AT THE BUFFALO GENERAL ELECTRIC CO.
(Courtesy Bailey Meter Co.)

New Accuracy and Precision in temperature and pressure control

. . .

NOTE SPECIAL FEATURES OF NEW TAYLOR RECORDERS AND REGULATORS

WITH the new Recording Thermometers and Recording Regulators Taylor takes another step forward in providing industry with the most up-to-date and efficient temperature and control equipment. In appearance, in design, and in construction these new instruments represent a marked advance. Their simplified and stronger construction assures an even greater degree of accuracy than previous Taylor instruments for the same purpose. The die-cast rectangular case is the first noticeable feature. Finished either in black or white enamel, this dust- and moisture-proof case combines beauty with modern efficiency in design. Note other features below. For any other information regarding these new instruments and their use in your plant, get in touch with a Taylor Representative. Or write Taylor Instrument Companies, Rochester, N. Y.



NEW TAYLOR RECORDERS

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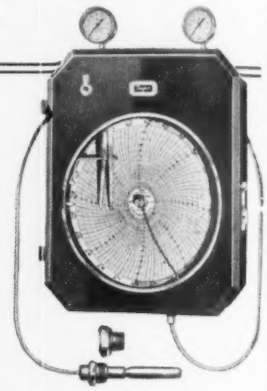
Outstanding Features

1. Improved mechanism with much lighter movement. Small, non-corrosive bearings and pivots reduce frictional forces and vibration. Result—more accurate performance.

2. Longer and more flexible pen-arm made of stainless steel. Gives better chart records due to less pen friction.

3. Micrometer adjustment of precision accuracy for setting pen-arm. Minor adjustments are easier.

These general purpose recording thermometers and pressure gauges come in one-, two-, and three-pen designs. They are available as mercury-, vapor-, or gas-actuated instruments.



NEW TAYLOR RECORDING REGULATORS

. . .

Outstanding Features

Add to the three points mentioned on the new Taylor Recorders:

1. New method for balancing instrument performance to time lag in apparatus. Results in optimum control for given set of operating conditions.

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4. Air pressure compensator. Results in accurate control when air supply varies.

These general purpose recording regulators for temperature and pressure are available with mercury-, vapor-, or gas-actuated tube systems.

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Indicating • Recording • Controlling
TEMPERATURE and PRESSURE INSTRUMENTS
† The name Taylor now identifies our complete line of products including Tycos instruments.

INSTRUMENTS

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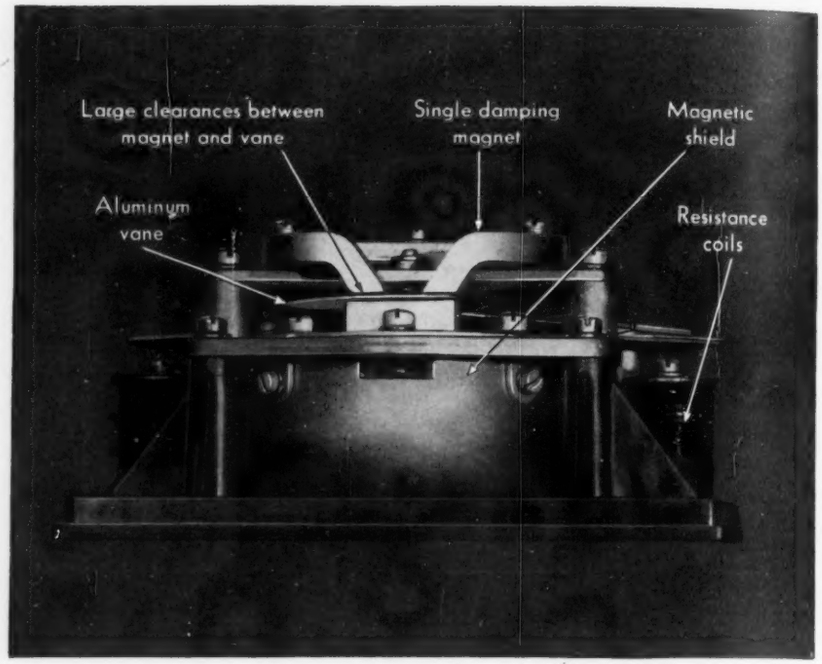
Instrument Users

WILL APPRECIATE THE MAGNETIC-DAMPING FEATURE IN THESE NEW G-E PORTABLES

WHY? Because the pointer overshoots only about 5 per cent. This is ideal for a portable instrument and makes for quick and accurate reading.

Another reason: magnetic damping permits the use of large clearances between the magnet and the vane, and with large clearances a slight change will not alter the damping characteristics. Thus, there is little likelihood of mechanical trouble developing. Accuracy is permanent. G-E Type AP-9 instruments are good for lifetime service.



Type AP-9 voltmeter, which is typical of these new G-E portable electric measuring instruments. The line includes a-c. ammeters, milliammeters, voltmeters, and wattmeters, in all standard ratings.

ONLY ONE MAGNET AND ONE VANE

Note how magnetic damping is obtained. An aluminum vane is mounted in the field of a permanent magnet. When the instrument pointer moves, the vane moves. The eddy currents set up in this vane give the necessary damping effect. Only one permanent magnet and one vane are required.

MANY OTHER GOOD FEATURES

You will also like the appearance of these new instruments. They are neat and compact, like a modern camera. They are of just the right size for a portable; are strongly built to stand rough usage; and have the degree of accuracy — within ¾ of 1.0 per cent — that is most suitable for commercial use.

Inquire about the AP-9 portables through the nearest G-E office. Ask for Bulletin GEA-1784, which gives complete information. If you prefer, address General Electric, Dept. 6M-201, *Schenectady, N. Y.*

610-77

GENERAL ELECTRIC

EDITORIAL COMMENT

In This Issue

◆ Although it makes CO_2 recorders, the Permutit Company is primarily a water-softening firm. Its automatization of this process, therefore, should be of direct interest to all readers concerned with processing, and the article by **Eric Pick** may inspire them to conquer a few more variables.

◆ Talk about coincidences! The **area meters** dealt with in the handbook instalment this month are flow meters with a constant-differential characteristic that makes them widely useful. There being little about them in the literature—practically nothing original outside of the brief Chapter 6 of the A.S.M.E.'s report—it seemed a good idea to fill the gap. This was done a few days ago. Now for the coincidence: To verify some assertions, we called up a firm that makes area meters. Next day, at the meter session of the A.S.M.E. convention, who should our next-seat neighbor turn out to be but the very expert who had taken our 'phone call—C. A. Dawley. . . . And that's not all: After the meeting Mr. Dawley remarked, "Good for you to pick Chapter 6 to pieces. Recent progress made a new treatment necessary since the time *I wrote it.*" . . . Praise from Sir Hubert; but what is needed *now* is for meter-specialist readers to show up the flaws in our analysis. Criticisms welcomed!

◆ Also in this issue—not in type but woven into every page of it—are the publisher's and editor's heartfelt wishes to each and every subscriber for a Christmas Day full of unclouded merriment, and for a New Year replete with material prosperity and spiritual joy. America IS pulling through, thanks to the efforts of valiant Americans—among whom are numbered those whose love for instruments endows them with a sense of values.

◆ ◆ ◆

The Front Cover

◆ Metering and control equipment for combustion and feed water at the C. R. Huntley Station of the Buffalo General Electric Co., impressively grouped by the Bailey Meter Co.

Domestic Meter Nonsense and Logic

MAKING a political football out of a technical issue is folly. Take for example the controversy now raging in New York City over water meters. *Instruments*, of course, is in favor of selling water on the basis of the quantity supplied, instead of on a flat basis for each size and class of building, but some of the publicity-seeking self-appointed "leaders" on our side are making such wild assertions that we are shocked to find ourselves in such company, and deplore the harm to our cause. For example, the assertion that leaky faucets and other household wastes alone amount to a fantastic quantity—which plain arithmetic shows to be about 25% of the supply!

Vehement opponents of meters—even more intemperate in their statements—are dragging out all the silly outworn socialistic rot, and making up some new bed-time stories, such as the one about sewers: "Health experts" (unnamed) are said to have "proved" that leaky faucets, and housewives who let the water run while they are out marketing, are a blessing in disguise, because if it were not for the consequent flushing, sewers would soon clog with foul accumulations, New York would smell like some Balkan towns, and New Yorkers would die like flies! As if there were no hydrants; as if it never rained!

Then, too, there is the class argument, as phrased by the general manager of the "Greater New York Taxpayers' Association":

> With the profligate wastage of water by our tenant population, owners of housing property, under the metering system, would be compelled to pay three times as much as they now pay for water.

In other words, landlords are now paying one-third of what they would if apartment houses were metered—according to their own association's general manager—and it's quite all right, implicitly, to let the brunt of water taxation be borne by tax-payers who consume little water, such as banks and department stores.

In our opinion, the proposal to install one water meter in each apartment house does not go far enough. What is needed is to meter every individual dwelling, whether it be a private house or an apartment.

Under the plan we really should like to see put into effect, every private house would have one water meter, but every apartment would have *two*. Every tenant would buy cold water from the city, at one rate and hot water from the landlord at a higher rate, thus paying the city through him for the water itself and him directly for the fuel required to heat the hot water consumed.

This would not only be equitable by reason of making each tenant pay in proportion to his water and fuel consumption, but it would prevent mischievous tenants from deliberately wasting water and fuel paid for by landlords. We hear that every winter, in some apartment houses where steam is turned off at 10 p. m., some tenants fill the bathtub with hot water and keep it running, with the bathroom door open, whenever they "throw a party" and stay up late.

Which reminds us of the waste of steam and of the injustice of having all scrupulous tenants pay indirectly for steam wasted by careless or mischievous tenants. Our platform, then, reads:

"A cold water meter, *a hot water meter, a steam meter*, a gas meter and a watthour meter in every apartment!" M. F. Behar

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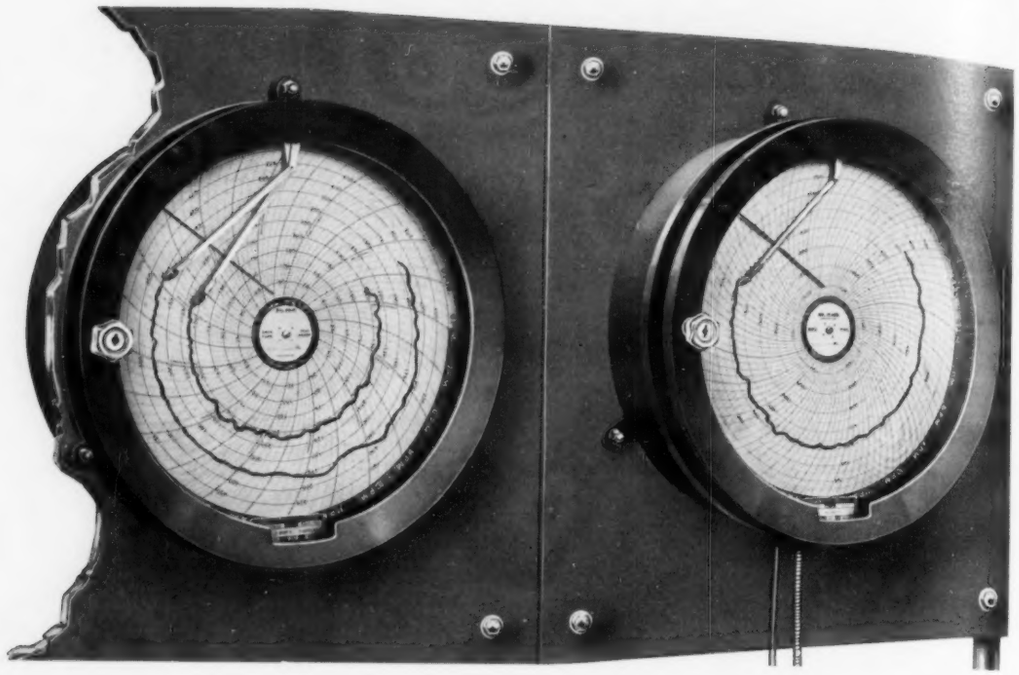
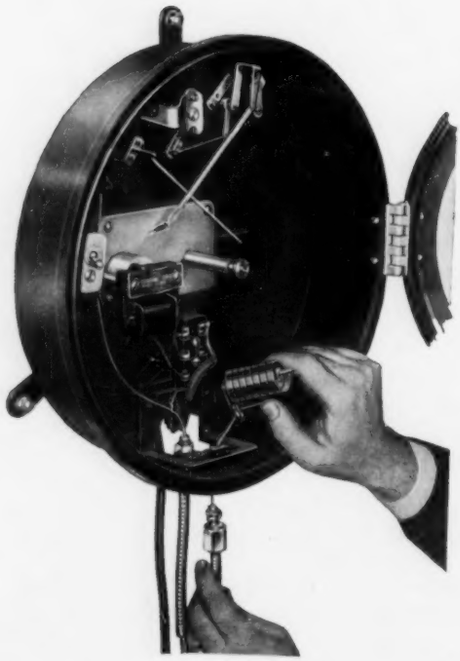
The Counter Reads 72

In calling attention to the fact that *Instruments* now ends its sixth year, we make only two brief comments: (1) If it were not for the *growth* of interest in measurement and control, we could not have survived. (2) This growing interest indicates that although the financial structure of industry is still shaky, its foundations of enlightenment and of striving for progress remain as solid as ever.

We invite comments from both old and new readers. Are we giving you exactly what you want? What improvements (within reach, of course) would you suggest?



ONE CASE—



for Flush, Front-of-Board or Wall Mounting- At No Extra Cost!

Today one important factor in instrument selection is economical cost—and the saving offered by a die-cast case, interchangeable to flush, front-of-board or wall mounting at no additional cost, is worthwhile considering. This new Brown Universal Case, standard for all Brown circular-case instruments, is completely interchangeable. In addition, this same case may be back or bottom-connected.

Illustrated at left is the Brown Recording Thermometer with this new case, showing how the interchangeable plates may be removed, permitting the range to be changed or the instrument to be converted to a two- or three-pen Recorder.

Send for complete details—ask for Catalog 6702.

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Brown Instruments

"to measure is to economize"

Automatic Control Instruments Applied to the Zeolite Water Softening Process

By ERIC PICK*

INTRODUCED to American industry more than twenty years ago, the zeolite process of water softening has found wide use in most branches of industry and many improvements have been made in the equipment used. Zeolite is a granular insoluble material, and water is softened by merely passing through a bed of it. After the rated capacity of the zeolite has been reached, the accumulated hardness must be removed. This regeneration is carried out by passing a solution of common salt brine through the softener. Just before regeneration or brining, however, reversal of flow of water through the softener, termed "backwashing," is usually necessary in order to cleanse and regrade the bed. After brining, rinsing is of course necessary to prevent salinity of treated water. Thus the cycle of operations consists of (1) softening, (2) backwashing, (3) brining and (4) rinsing.

In manually operated zeolite softeners, seven or more individual valves are needed to accomplish this cycle. Simple as are the operations involved, it is necessary to operate the valves in the correct sequence in order to obtain correct performance of the softener. The human element, consequently, has played such a critical part in every installation that its minimization has been diligently striven for. Its total elimination, now announced, is due entirely to application of modern Instrumentation principles. A description of the means should therefore interest the readers of *Instruments*.

The recently perfected single control valve is the "heart" of the automatic zeolite plant and will therefore be described first, since all the instruments, switches, etc., co-act as a team to operate this central "traffic manager."

THE CONTROL VALVE

This multi-port rotary valve embodies a new principle in valve design, using a flat, hard rubber faced, distributing slide or disk, rotated from one position to another in contact with a stationary bronze port plate (see Fig. 1). The hard water, under pressure, is admitted to the *top* of the disk and is then directed by an *opening* in the disk to a port plate opening.

The water leaving the softener flows through a *cavity* in the contact surface of the disk to the outlet. The inlet water pressure acting on the top of the disk, aided by the pressure of a spring, holds the valve disk firmly against the port plate. This pressure, and a certain amount of flexibility inherent in hard rubber, insure a valve which remains tight at all times. Yet the action of the valve is smooth, since the nature of the materials used makes it impossible for the moving parts to corrode or stick together. All port openings and passages within the valve have a cross section at least equal to the sectional area of the connecting piping to avoid undue throttling and excessive pressure losses.

The valve stem is rotated by means of a completely housed worm gear reduction which insures a slow and steady rate of rotation, thus providing a gradual increase and decrease of the rate of flow at the start and end of each operation, so that the zeolite and gravel supporting beds are protected from any shocks or disturbances.

After the rated capacity of the zeolite has been reached, the valve being in the softening position, the valve disk is turned to the backwashing position. The path of travel of the water through the valve and softener with the valve in its various positions will now be described.

Backwashing—In the backwashing position (Fig. 3) the incoming hard water is admitted by the valve disk opening to the bottom of the softening tank and flows up through the zeolite, thereby removing any dirt from the top of the bed and at the same time hydraulically grading the zeolite granules by carrying the finer grains to the top. These finer grains in the top layer assist in uniform distribution of water and brine. The water flows from the top of the softener to the valve which directs it to the backwash outlet. A rate-of-flow controller (Fig. 2) in the backwash outlet line maintains a definite head of water behind an orifice located in the sump, thereby providing a constant rate of flow, irrespective of variations in pressure that may occur in the supply line. After the softener has been backwashed, the valve disk is turned to the brining position.

Brining—In the brining operation (see Fig. 4) the hard water is admitted by the valve disk opening to a hydraulic injector which draws the brine from a brine measuring tank and discharges the mixture of concentrated brine and water into the top of the softener. The bottom of the softener is connected by the valve disk cavity to two waste lines (one being the above-mentioned backwash outlet, and the other being the rinse outlet to be referred to later). Due to this double outlet, there is a minimum resistance to the flow from the softener so that the injector works against practically no discharge pressure, which insures efficient and positive injection of brine. When the correct quantity of brine has been introduced into the softener (as measured by drop in level in brine measuring tank) the valve disk is turned to the rinsing position.

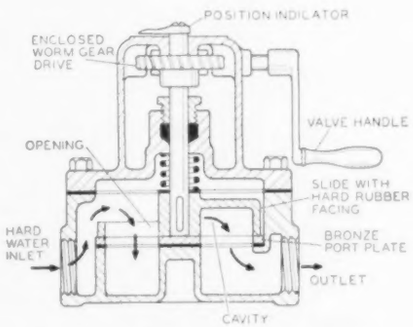


Fig. 1. Section through Control Valve (manual type).

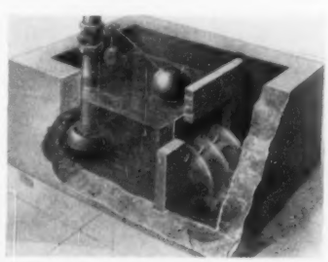


Fig. 2. Backwash Control.

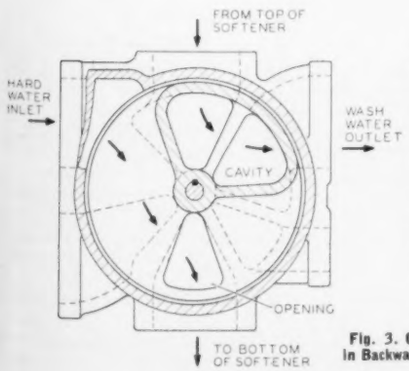


Fig. 3. Control Valve in Backwashing position.

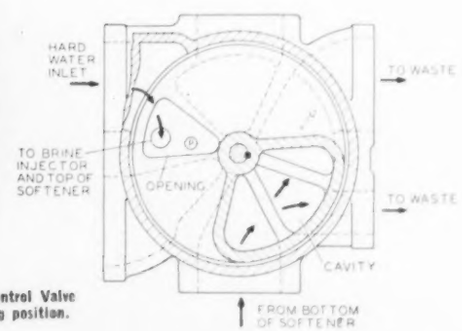
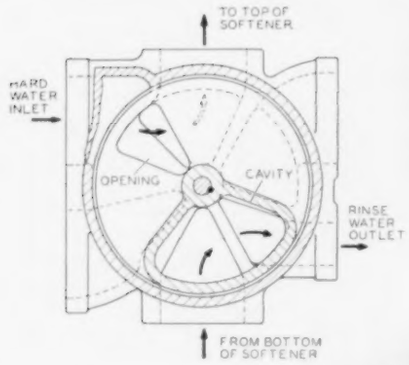


Fig. 4. Control Valve in Brining position.

*Mechanical Engineer, The Permutit Co., New York.

Fig. 5. Control Valve in Rinsing position



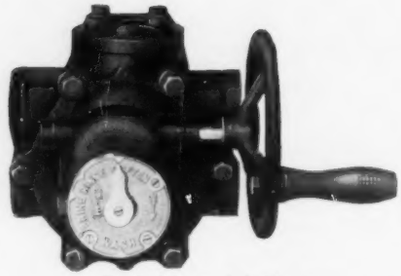
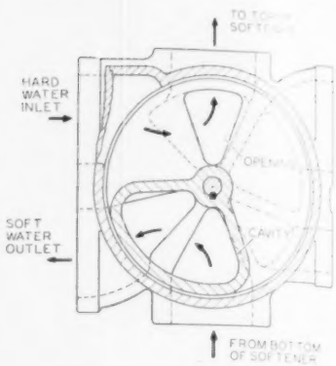


Fig. 7. 1½" Control Valve arranged for Manual Operation. (One-sixth actual size)

Fig. 6. Control Valve in Softening position



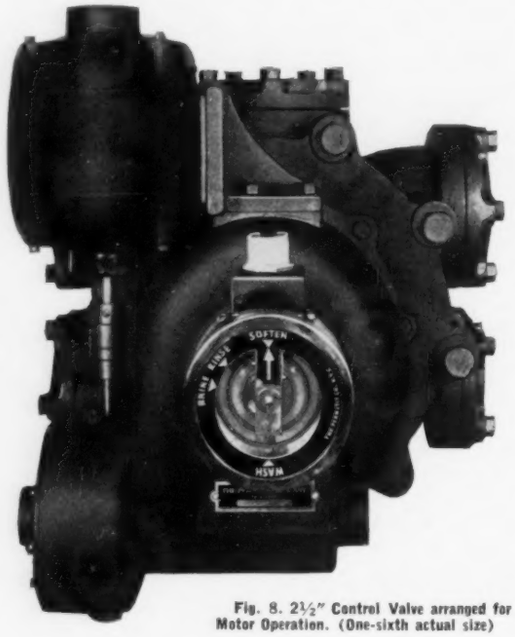


Fig. 8. 2½" Control Valve arranged for Motor Operation. (One-sixth actual size)

Rinsing—In the rinsing operation (see Fig. 5) the brine is driven down through the zeolite bed by fresh water, admitted by the valve disk opening to the top of the softener. The spent brine is rinsed out and passes from the bottom of the softener through the cavity in the valve disk and the rinse outlet to the sewer. The rinse outlet is provided with a rate of flow controller (similar in construction to the backwash rate of flow controller illustrated in Fig. 2) which insures correct duration of passing the brine through the zeolite, and results in high efficiency of regeneration. When all brine has been rinsed from the softener, the valve disk is turned back to the softening position.

Softening—In the softening position (Fig. 6) the entering hard water is directed by the valve disk opening to the top of the softener and passes down through the zeolite bed. The soft water flows from the bottom of the softener and is directed through the valve to the soft water service line.

When it is desired for any reason to by-pass the softener and to supply hard water to the point of use, the valve disk may be turned to an "off" position, which lies about half way between the brining and backwashing positions, and in which hard water is admitted by the port plate opening directly to the service line. In this position the ports leading to the top and bottom of the softener are closed and the softener tank is entirely disconnected from the supply and service pipes.

Thus, the single control valve—even without any automatic operation—has *simplified* the process: instead of a plurality of valve wheels, handles or levers, there is only one wheel to turn and one rotary indicator to watch. It is impossible to alter the sequence. Even an operator unfamiliar with the working of the softener and with the principles involved, can operate the equipment without risk of any mis-step. Fig. 7 shows a 1½" single valve arranged for manual operation.

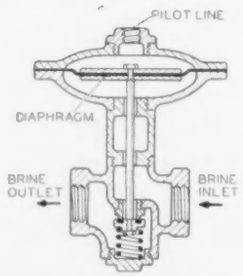


Fig. 9. Pilot-operated Diaphragm Brine Valve.

OPERATING PRINCIPLE OF FULLY AUTOMATIC SOFTENER

With this single control valve, moreover, the application of automaticity becomes a relatively simple matter. First, we motorize the valve and obtain the device shown in Fig. 8 (a 2½" control valve). Next, we arrange for a schedule of shifts from one position to the next and back to the first. This cycle is composed of four periods, the duration of each of which is governed by one specific requirement, as follows:

1. *Softening*—Until softener needs regeneration;
2. *Backwashing*—Until impurities are washed away;
3. *Brining*—Until correct quantity has been injected;
4. *Rinsing*—Until brine is rinsed away.

When a predetermined quantity of soft water has been delivered and the softener needs regeneration, a meter in the soft water line (pre-set to this gallonage) closes a switch which sets the motor in operation to turn the valve to the backwash position.

Next, an automatic time switch determines the duration of backwash and then causes the valve to be turned to the brining position.

In the brining position, hard water is admitted to a pilot line connected to the control valve (connection P in Fig. 4) and opens the diaphragm brine valve, thereby permitting the flow of brine through the injector to the softener.

When a predetermined quantity of brine has been withdrawn, a float-operated switch in the brine measuring tank starts the motor which turns the valve to the rinsing position. Then the automatic time switch again assumes control and, after a predetermined period of rinsing, causes the motor to turn the valve back to the softening position, thus completing the cycle of operations.

This cycle is automatically repeated at the end of each softening run—every 3 to 5 hours where the softener is "worked to capacity" or every week or so where little water is being used.

The brine measuring tank is filled with brine from the salt storage tank. The connecting pipe has a flow restriction so that considerable time is taken to refill the brine measuring tank, thus preventing the brine measuring tank from filling up while the brine is being injected into the softener. A constant head box, equipped with a float valve, refills the salt storage tank with water as the brine flows into the brine measuring tank.

THE ELECTRIC CONTROL

As shown in Fig. 11, the motor for operating both the single control valve and the circuit breaker is connected to a power circuit and operates whenever the magnetic switch is closed. The magnetic switch closes when its solenoid is energized by the control circuit; when the solenoid is again de-energized, the magnetic switch is opened by a spring and the motor is stopped. Any voltage between 110 and 550 is suitable for the power circuit, either alternating current (single-, 2- or 3-phase and any standard frequency) or direct current. The control circuit, however, requires alternating current of 110 or 220 volts. When only direct current is available a small converter is used to supply the control circuit.

Understanding of the control system is greatly facilitated if it is kept in mind that the control circuit includes four branches, one for each of the four operating steps. Each of these branches includes two switches; a circuit breaker closed at the beginning

of each operation, and another control switch, which closes and so completes the control circuit at the end of each operation, when the valve is to be turned to its next position. As soon as the next position is reached, the circuit breaker brush, connected to the valve stem, interrupts the control circuit, stopping the motor, and coming in contact with the next branch of the control circuit.

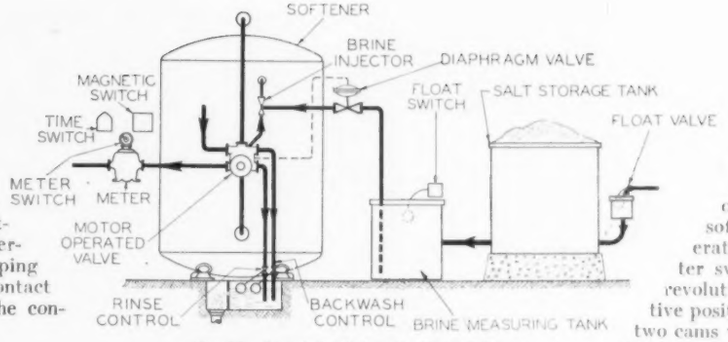


Fig. 10. Layout for Automatic Water Softener.

THE MAIN CONTROL SWITCH

By throwing the control switch to the "hand" position, the solenoid of the magnetic switch is energized and all other control devices are rendered inoperative, which keeps the motor running continuously. In this manner, the control valve may be moved to any position desired and then stopped by throwing the switch to the "off" position.

When the control switch is in the "auto" position as shown in Figure 11, the softener is under automatic control.

THE METER SWITCH

The meter switch is operated by means of the water meter through a one-way drive clutch A. When the water meter drives the meter switch cams, the one-way drive clutch B merely slips. When the meter switch cams reach the position shown in figure 11, the switch M1 is closed and regeneration is initiated. In the course of regeneration the re-setting motor is energized and turns the meter switch cams through the one-way drive clutch B — while clutch A slips—until the notch on its cam opens the switch M2. This places the meter switch in readiness for the next softening run. It is thus seen that, during each complete cycle of operations consisting of a softening run and the regenerating performances. the meter switch cams make one full revolution. By changing the relative positions of the notches on the two cams with respect to each other, the number of gallons passing through the meter between regenerations can be varied.

THE INTERLOCK CONTACT

In the actual design, the circuit breaker has an interlock contact which is closed in softening position but open in all other positions of the control valve. This contact is not used in most single unit installations and has, therefore, not been shown in Fig. 11.

When two automatic softeners are installed, the interlock contact of one unit is wired into the meter switch control circuit of the second unit, and vice versa, to prevent simultaneous re-

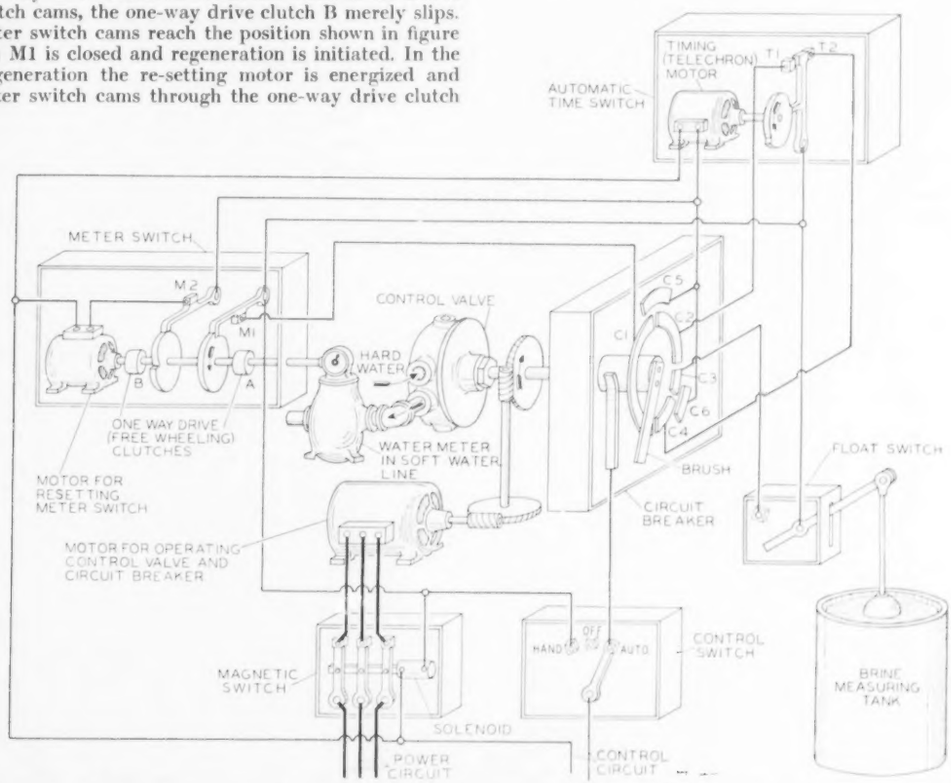


FIG. 11. SCHEMATIC DIAGRAM OF AUTOMATIC WATER SOFTENER CONTROL DEVICES AND THEIR OPERATING CONNECTIONS.

1. **SOFTENING.** The softener remains in the softening position until a predetermined quantity of soft water has been delivered to service. Then the meter switch M1 closes and initiates regeneration. The controls are shown in this position.

2. **CHANGE FROM SOFTENING TO BACKWASHING.** The closing of the meter switch M1 establishes a circuit through the control switch, the circuit breaker brush, contact strip C1, switch M1 and the solenoid. The magnetic switch closes and the motor runs and turns both the control valve and the circuit breaker brush until the brush slips from contact strip C1 to contact strips C2 and C5 when the backwashing position is reached. This interrupts the control circuit and the motor stops.

3. **BACKWASHING.** The circuit breaker brush has established a circuit through contact strip C5 which includes in parallel connection the timing motor of the automatic time switch and the re-setting motor of the meter switch. (The re-setting motor runs and turns the cams of the meter switch to the zero position where its circuit is interrupted by the opening of switch M2.) The timing motor turns the timing cam until the switch T2 opens and T1 closes after a predetermined duration of backwashing.

4. **CHANGE FROM BACKWASHING TO BRINING.** The closing of the time switch T1 establishes a circuit through the circuit breaker brush, contact strip C2, switch T1 and the solenoid, and the valve is turned until, in the brining position, the circuit breaker brush moves from contact strips C2 and C5 to contact strip C3 whereupon both the main motor and the timing motor stop.

5. **BRINING.** As soon as the predetermined quantity of brine has been drawn by the injector from the brine measuring tank the float switch closes.

6. **CHANGE FROM BRINING TO RINSING.** The closing of the float switch establishes a circuit through the circuit breaker brush, contact strip C3, the float switch and the solenoid and the valve is turned until, in the rinsing position, the circuit breaker brush runs from contact strip C3 on to contact strips C4 and C6.

7. **RINSING.** The circuit through strip C6 again starts the timing motor which maintains the rinsing operation until the timing cam opens switch T1 and closes switch T2.

8. **RETURN TO SOFTENING.** The closing of time switch T2 establishes a circuit through the circuit breaker brush, contact strip C4, time switch T2 and the solenoid. The main motor runs until, in the softening position, the circuit breaker brush leaves contact strips C4 and C6 and interrupts the control circuit as well as the timing motor circuit. The circuit breaker brush comes to rest on contact strip C1 but the control circuit is interrupted by the open switch M1 and the valve remains in the softening position until the meter switch M1 is again closed when the predetermined quantity of soft water has been delivered by the softener.

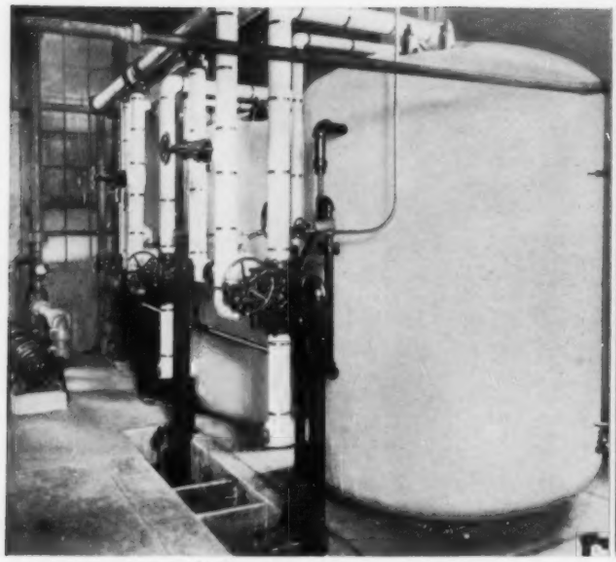


Fig. 12. Battery of Softeners with Single Valve (manual type).

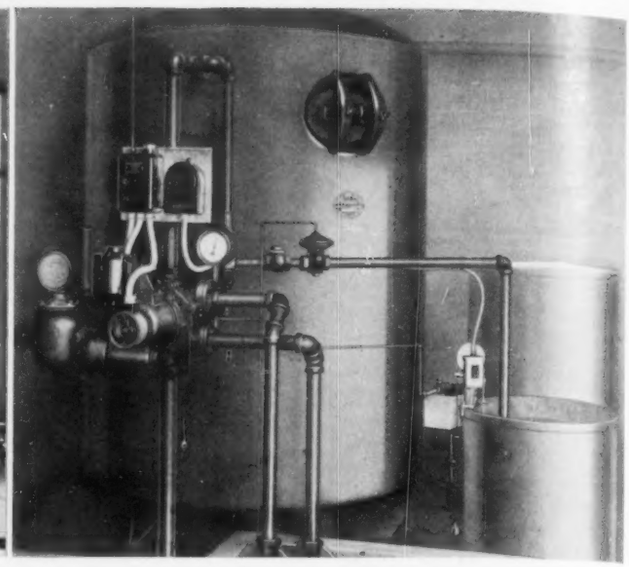


Fig. 13. Fully Automatic Water Softener.

generation of both softeners. Whichever softener starts to regenerate first retains the "right of way," and the second unit cannot go into regeneration until the first one has completed its operating cycle.

In cases where the pressure of the water supply is comparatively low, the interlock contact, in conjunction with a relay, may be used to operate a booster pump during regeneration, in order to furnish the rate of flow required for adequate backwashing.

If a plant operator wishes to be informed whenever the softener regenerates, a signal light may be connected to the interlock contact to flash during regeneration.

ALL VARIABLES ADJUSTABLE

It is a special feature of this automatic control system that all variables are adjustable independently of one another. The number of gallons of water passing through the meter in the softening run may be varied. The duration of backwashing as well as of rinsing may be varied by adjustment of the automatic time switch. The amount of brine withdrawn may be adjusted in the float switch. As previously explained, the rates of flow of backwashing and rinsing are likewise controlled and are adjustable. Thus all these variables can be adjusted so that the most efficient and economical operation of the softener results. After the adjustments have once been made, the automatic control mechanism will carry through each cycle as an exact duplicate of the first one.

ADVANTAGES OF AUTOMATICITY

Automatic softeners may be built of smaller dimensions than the manually operated type. Manually operated softeners are usually made large enough to run for 6 to 24 hours between regenerations in order to save the operator's time by reducing the frequency of regeneration. On account of the self-regenerating features, the automatic may be smaller and yet produce the same daily soft water output as the larger manually operated softener, without the excessive attention which a smaller manual softener would require. Thus a saving in first cost as well as in operating cost is realized.

Certain railroad water stations or other isolated plants may not have a regular attendant, but only an operator making occasional visits. Large water treatment plants including a number of zeolite units, together with other equipment, may be too much for one operator to handle efficiently. In either case the self-regenerating type is the solution.

Many factories have one operator assigned to several different duties. When such a hard-driven operator inspects the softener, he may find the softening run not yet complete but, to avoid overrunning, he may be tempted to regenerate prematurely and thus waste salt and water. On the other hand, the operator may not be there just when regeneration is required; the softener may be allowed to over-run, thus permitting hard water to flow to service. The automatic softener eliminates these difficulties. It carries out all operations automatically, thus saving attention. Regeneration takes place on time, so that the softener is neither regenerated too soon nor run beyond its softening capacity. Salt waste is avoided by the mechanical measuring of the correct quantity of salt brine. The control of backwashing and rinsing avoids waste of water in these operations and maintains the zeolite in a clean, active condition, and the slow turning of the control valve prevents disturbances of the zeolite bed. Thus, the production of only completely soft water at a minimum of operating expense is assured.

An operator in a hurry, a change in personnel, absence due to illness—none of these everyday occurrences can interfere with the quality of water delivered by the automatic softener.

The writer wishes to acknowledge the work of Messrs. E. Staegemann and N. E. Brice in the development of the single control valve and the automatic control system (covered by issued and pending patents) which can be applied to existing zeolite softener installations now equipped with individual control valves.

◆ ◆ ◆ ◆ ◆

After 25 years at 31 Union Square, the New York office of the **Taylor Instrument Companies** has been moved to larger quarters in the R.C.A. Bldg., Rockefeller Center, N. Y. City.

The **Moeller Instrument Co.** of Brooklyn, N. Y. (thermometers, mercurial vacuum gages and barometers, etc.), have appointed the following sales agents and representatives: J. F. Butler, New Orleans, La.; Engineering Sales Co., Milwaukee, Wis.; P. E. Fallon, Houston, Texas; H. C. Freese, Kansas City, Mo.; Himelblau, Byfield & Co., Chicago, Ill.; L. C. Holmes, Washington, D. C.; T. R. Law, Angolia, Ind.; Jensen Instrument Co., Los Angeles, Calif.; U. H. Nickerson, Boston, Mass.; The Precision Instru. Sales Co., Seattle, Wash.; J. C. Ross & Co., Portland, Ore.; S. & S. Engineering Co., Charlotte, N. C.; E. C. Shriner, Pittsburgh, Pa.; A. C. Sprout, Oakland, Calif.; Lee W. Tremblay, Philadelphia, Pa.

The John Scott Medal for scientific achievement has been awarded by the City of Philadelphia to **Dr. Frank Conrad**, Ass't Chief Engineer of the Westinghouse Elec. & Mfg. Co. Dr. Conrad had been honored previously for his achievements in radio: in 1928 by the University of Pittsburgh with the Sc.D. degree, and in 1920 he was recipient of the Edison Gold Medal for outstanding accomplishments in electrical engineering.

The Toledo Scale Company announces the appointment of **L. R. Boyer** to the Home Office Sales staff. Mr. Boyer will specialize in the sales of industrial type scales, including large capacity floor scales, auto truck scales, hopper scales and monorail scales. Mr. Boyer has had fifteen years' experience in the weighing industry. He is well known through his activity in connection with the U. S. Bureau of Standards Test Weight Cars and the National Association of Scalemen.

Flow Measurement and Control*

By M. F. BEHART

CHAPTER XXVI

AREA, FLOAT, WEIR, NOTCH, THERMAL AND MISCELLANEOUS INFERENTIAL METERS

1. Area or Geometric Meters

(a) Characteristics of the Area Class

(1) The measurement is of flow rate, practically of the instantaneous rate.

(2) Uniform scales are readily practicable, so that recorder charts are easily planimetered. Simple combinations of flow elements and time elements provide reliable integrations. *Note*—The "geometric" principle permits designing meters with various special scales which are frequently desirable in industrial processing work.

(3) Limit of error is theoretically constant from capacity load to extremely small flows. Available area meters are satisfactorily accurate down to less than 5% of capacity and in some cases to 1% of capacity.

(4) Calibration is always required in practice. Only a hypothetical "ideal" area meter, by virtue of its design and dimensions, can be a Standard instrument with a scale determinable by linear measurements and by fluid flow theory.

(5) Pulsating flows cannot be measured accurately. The markedness of this characteristic differs in the several types and in the numerous designs. Free-float types are the most unsuitable of all fluid meters in this respect, while some automatic-control designs have damping arrangements.

(6) With regard to temperature limits, maximum working pressures, cleanliness of fluid, etc., the characteristics vary widely.

(b) Definitions and General Principle

Under the heading of area meters it is customary to include a wide assortment of devices, some named area meters when brought out by their makers; some otherwise listed by their makers; most of them otherwise called by their users. Convenience seems to be the deciding factor in some texts; usage in others. The A.S.M.E. Special Research Committee on Fluid Meters states:

"Area" meters are those in the operation of which a variation of the cross-section of the stream under constant head is used as an indication of the rate of flow. For example, a tapered plug is suspended in an orifice, moving axially with the flow, which is vertically upward. The weight of the plug provides a definite pressure difference and the plug floats at such a height as will provide orifice area to pass the flow at this pressure difference.

No rigorous definition of the area class seems to have been laid down heretofore, probably because of the difficulty of framing one when official bodies came into being after so many different designs had, so to speak, already seated themselves in the section labeled "area" without producing official passes. Today, one cannot find the just formula between a loose wording that would take in some force meters (as does the A.S.M.E.'s), and a rigid definition that would bar nearly all commercially available area meters. Strictly speaking, there is only one true area or geometric fluid meter: an *ideal* one, which the author ventures to define by the characteristic equations

$$\left\{ \begin{array}{l} Q = C_1 A \\ h = C_2 \end{array} \right\}$$

the physical significance of which is (1) that the volume rate of flow Q is a straight-line function of the area A of an orifice or other restriction through which all of the fluid passes; the fluid—whatever it be—flowing in a closed conduit, not in an open channel; (2) that this area automatically adjusts itself to the instantaneous values of Q, so that a pointer indicating A will indicate Q by traveling over a scale in which A has been multiplied by C_1 which is an

*Part Six of *The Manual of Instrumentation.*
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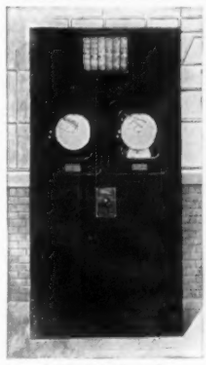

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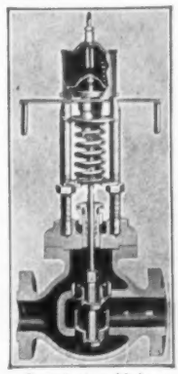

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A.S.T.M. Manual on Presentation of Data. (Sponsored by) Committee E-1 on Methods of Testing. American Society for Testing Materials, Philadelphia, 1933. Paper, 6x9 inches, 48 pages. Price 50c.

Some of the principles of efficient presentation of data are correlated by statistical experts and made available in convenient form with a profusion of tabular and graphic illustrations and of references to comprehensive treatments of topics dealt with. Emphasis is placed on selecting essential information, condensing it and presenting it in readily interpretable form. Methods of computation are given. Comments on various methods, and recommendations on what relevant information should accompany data, are made. A table of squares and square-roots is appended. If you have occasion to make tests, get this pamphlet! M. F. BÉHAR (1)-**B-**

Theory of Thermionic Vacuum Tubes. By E. LEON CHAFFEE, McGRAW-HILL Book Company, Inc., New York, 1933. Cloth, 6¼ x9¼ inches, 652 pages. Price $6.00.

This book is undoubtedly the most comprehensive work on the subject of low power vacuum tubes which has yet appeared in this field of engineering science. The author, who is an authority on and an original investigator in various phases of the subject states that the book was written primarily as a text book from his lecture notes used at Harvard University since 1922. The result of his efforts will undoubtedly serve as a reference work of great utility because of the rigid and thorough manner in which he has treated the subject.

Because the subject is an extensive one "the author has endeavored to present only the fundamental principles of this subject, avoiding discussion of the multifarious circuits in which the vacuum tube may be used. The circuits and applications of vacuum tubes change from year to year but the fundamental theory is the same for all time. With an understanding of the principles, any circuit and any application can be analyzed." The book is intended to cover only the theory of operation of vacuum tubes at low power. A second volume to include the theory of power amplifiers and oscillators, gas-content tubes, rectifiers, etc., is promised at some future time.

The author has definitely enhanced the usefulness of this book by identifying with an asterisk (*) certain sections which go into considerable detail or which involve special cases of a theorem previously developed. Furthermore, he has been unusually thoughtful of the readers' customary predicament in remembering the significance of the large number of symbols involved. A list of symbols (4½ pages) is given at the beginning of the book for convenient reference. A short chapter (VI) is devoted to a discussion of "Nomenclature and Letter Symbols" in which some general principles are set down which greatly assist one in identifying all symbols.

The book opens with a classification of vacuum tubes and a brief historical review of the subject. In chapters II, III and IV fundamental physical principles of atomic electricity are discussed. The properties of molecules, atoms, and electrons in vacuum and in rarefied gaseous atmospheres and the theory of electron emission are clearly enunciated. The description of the various practical sources of electron emission and the physical aspects of vacuum tubes are given in chapter V. In the several chapters following, the theory of operation, electrical characteristics and circuit applications of 3-electrode tubes are thoroughly treated. The mathematical interpretation, graphical illustration of characteristics

(Continued on Page 222)

invariable product of approach factor, contraction factor, friction factor, etc.; and (3) that h, the differential across the "orifice" or measuring section, or the pressure drop "through the meter," always remains constant.

In other words we must have an automatic ideal valve; it must automatically vary A in order to maintain h constant; and it must perforce possess ideal characteristics so that the indication of orifice area can serve as a correct indication of volume rate of flow.

It already has been made evident, in §4 of the preceding chapter on head meters, that even for the restricted case of metering one homogeneous fluid entering the meter at constant temperature, constant density and constant viscosity, the coefficient of discharge varies with the volume rate of flow; and an examination of the derivation of orifice meter equations relating $\mathcal{Q}$ to h brings out that even slight changes in various dimensions of an orifice meter must result in considerable changes in its coefficient. In *any* inferential meter depending on a constriction of the channel and on a resultant differential, the simplest relation between $\mathcal{Q}$ and h is

$$\mathcal{Q} = CM\sqrt{2\,g\,h}$$

in which the meter constant

$$M = A_2\sqrt{\frac{(A_1/A_2)^2}{(A_1/A_2)^2 - 1}},$$

depends not only on the absolute size of the meter but on the area ratio. This is not the diameter ratio $r = D_2/D_1$ but the ratio of upstream area A_1 to *effective* area A_2. The effective area is identical with the orifice area (except for skin friction) when the diameter ratio is unity, but as the diameter ratio is made smaller it diminishes to as little as 60% of the orifice area, approaching assymptotically a final value which is that for a small sharp-edge orifice discharging a fluid of given viscosity into a large space under a given differential.

In a geometric or variable-orifice meter, merely keeping h constant cannot prevent the approach factor from decreasing appreciably as the orifice area decreases, nor the contraction factor from doing the opposite, until the orifice becomes so small in relation to its edges that it no longer is an orifice and the formulas no longer apply.

It may be proved, too, that if instead of an orifice that remains concentric (as does the opening of an iris diaphragm) we have a gate form, the shape of the full opening would have to be suited to the properties of each metered fluid. And if we have an odd-shape opening of indeterminable effective area, $\mathcal{Q}$ is indeterminable from theory.

On top of all that, if our device is to be used for metering gas on a quantity basis, so as to register standard cubic feet on a direct-reading counter, it must automatically correct the successive volume increments for variations in pressure, temperature and specific gravity. Somewhat similar complications arise if the device is to be used for metering steam W and not $\mathcal{Q}$.

In short, several problems must be solved before we can have an area scale that can be read in flow units; the geometric principle is not so simple; but it does make possible beautifully simple solutions of some problems. For example, one solution of the problem of proportioning gate lift to flow rate is shown in Fig. 26-1, reproduced with a slight alteration from the A.S.M.E. Report, from which we quote:

The velocity through A_2 is made up of the initial velocity v, at A_1 and the additional velocity produced by the static head h. The amount by which the velocity at A_2 is increased in excess of the velocity due to h, is expressed by the coefficient of approach F, which is variable and increases as gate G is raised. In other words, with constant head h, decreasing increments of A_2 would be required for equal increments in the quantity flowing. Then if the linear opening of gate G is to be in direct proportion to the flow, the opening A_2 would not be a rectangle but a tapered form, wider at the bottom than at the top.

To this we must add that this solution only applies to one specific set of conditions, under which A_2 is proportional to indicated A. In the Report, A_2 is the actual area; in Fig. 26-1 we have added dotted lines to show that it is the *effective area* that counts.

Elimination of the approach factor is another problem. An interesting solution is shown in Fig. 26-2, also reproduced with a slight alteration from the same Report, which we quote again:

To avoid the application of a variable coefficient F and to permit using an orifice in which the area is directly proportional to the height, or to the travel of the moving element, the design of area meters is usually arranged to take the total head at A_1, that is, the impact head, which is the sum of the head due to velocity of approach and the static head h. Call this total head H. With a design which in effect accomplishes this result, the factor F is eliminated and the orifice A_2 may be of rectangular form or any equivalent construction in which the area A_2 increases directly as the travel of the gate G.

On this we may comment that the approach factor is not eliminated but minimized, as a comparison of approach factor formulas with the square law of impact tubes will show. Since H is kept constant, $H - h$ will vary with Q, hence with A; but the curve of $H - h$ against A will not coincide at all points with the curve of F against A, and gate lift (in the illustrated case of a parallel-side opening) will not be exactly proportional to flow. Here, too, the Report's figure fails to distinguish between the actual area and effective area.

As with other inferential meters, most of the actual designs of area meters do not employ the "pure" geometric principle. Some are frank compromises, as in the case of Fig. 26-2 where an impact opening is used, so that the head is not "the difference between the *static* pressures at two sections of the stream." In other designs, the constant head is not that between two definite or determinable sections of the stream. Even in the gate type, which is the "purest," we cannot hope to use true vena contracta connections (which many authorities consider the most desirable) because the distance from the orifice plate to the vena contracta increases as the orifice area decreases, so that in an "ideal automatic valve" if we provide an arrangement to hold constant a differential h_1

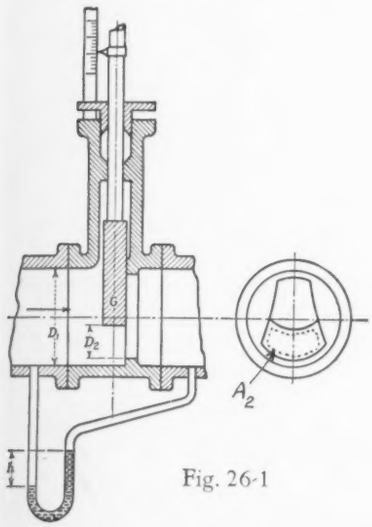

Fig. 26-1

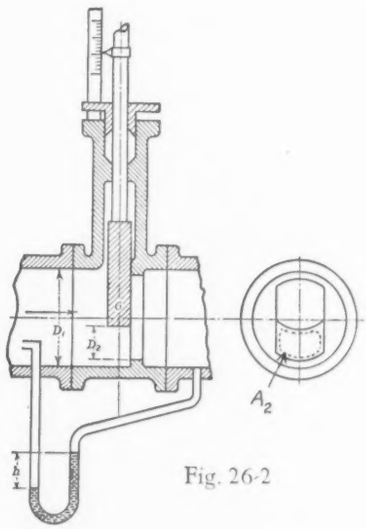

Fig. 26-2

measured with the downstream tap in one particular location (say half a pipe diameter) we shall find that the differentials h_2, h_3, . . . measured with "corner connections" or with "pipe connections," etc., will vary. This is true of all area meters of the gate type, and would seem to apply to all other forms of area meters.

The most "impure" types, of course, are those with the area-regulating element entirely submerged, hence responding to stream impact, hence sensitive to viscosity, density and pressure variations. Which suggests a classification along this line.

(c) General Classifications

Before passing on to the distinct types based on forms of primary elements, it is not amiss to establish a classification of area meters based on the principles they employ. On this basis it turns out that commercially available area meters fall into one of two general types:

(1) *Head-regulating Type*—Meters in which there are, as in head meters, connecting pipes, or passages drilled or cast in the meter, whereby the upstream and downstream pressures are taken off for the purpose of keeping the head constant, and are utilized for automatically proportioning the area to the flow (volume-rate or quantity-rate as the case may be). This general type is the one to which the most advanced area meters belong.

(2) *Mixed Type*—Those depending, for constancy of head, upon the weight (or buoyancy) of a flow-restricting element, and, for flow measurement, upon the position of this same element. By reason of the impact effect, this is really a hybrid of the area class and the force class (rather than an intermediate class), but whatever we call this general type, it fills a most useful place, for it includes all meters of the free-float type and most of those of the orifice-and-plug and cone-and-disk types.

Some authorities consider "flow provers" [see Chap. XXIII, §8, Art. (e)] and multiple-orifice meters to constitute a third general type of area meter. In

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(Continued from Page 220)

and circuit diagrams are abundant and logically placed.

Regeneration with triodes, low power resistance coupled, impedance coupled and transformer coupled triode amplifiers are discussed in separate chapters, as are diode and triode detectors. Multi-electrode tubes are analyzed from the standpoint of fundamental theory. The entire book gives one the impression of orderly completeness. Much of the material is original w rk of the author although the contr. utio.s of others are well classified and many references are given. The typography and illustrations are excellent and it is certain that any one who is interested in the fundamentals of the subject or is engaged in the design of vacuum tubes or apparatus in which tubes are used will find the book invaluable as a source of study and reference. A number of plates showing X-ray photographs of vacuum tubes are distributed through the book.

A. J. McMaster (5)-B-

MANUFACTURERS' NEW LITERATURE

In this department we each month list the printed matter issued by manufacturers. Unless otherwise noted, any of the items listed may be secured free upon application to the issuing firm. Manufacturers who have not yet sent in their printed matter are invited to do so.

A284 **Electrical Instruments.** 8-page bulletin GEA-1784 on medium-size portables of radically new design. General Electric Co., Schenectady, N. Y.

A285 **Surveying Instruments.** 20-page bulletin (in 3 languages) on new line including 3 remarkably advanced photo-theodolites. Officine Galileo, Firenze, Italy.

A286 **Photocell Applications.** 4-page bulletin entitled "Opportunities" shows varied uses. A. M. I. Distributing Co. (Electronic division), Grand Rapids, Mich.

A287 **High-pressure Gas Regulation.** Leaflet ADC-593 describes new 2-stage regulator with leak signal and other novel features. Air Reduction Sales Co., New York City.

A288 **Hydrometers.** 4-page Bulletin 1070 describes improved certified hydrometers. C. J. Tagliabue Mfg. Co., Brooklyn, N. Y.

A289 **Flow Indicator.** Loose-leaf on Type 18-A flow indicator for gasoline or Diesel oil. Commercial Engineering Lab's, Detroit, Mich.

A290 **Stroboscope.** Loose-leaf on Type II Ashdown motor-driven Rotoscope. Commercial Engineering Lab's, Detroit, Mich.

A291 **Instruments for Glass Control.** 8-page folder on polariscope, microscopes, etc. Bausch & Lomb Optical Co., Rochester, N. Y.

A292 **The Vapocarb Hump Method for Hardening** is title of thoroughly technical 12-page bulletin. Leeds & Northrup Co., Philadelphia, Pa.

A293 **Optical Gear Tester.** 4-page Catalog 563 of Société Genevoise d'Instruments de Physique describes apparatus for rapid tests of spur and helical gears $<4''$ diam. The R. Y. Ferner Co., Washington, D. C.

A294 **Industrial Temperature, Humidity and Pressure Instruments.** 80-page Catalog 6702 describes complete series of indicators, recorders, controllers, recorder-controllers, time-cycle recorder-controllers, accessories. The Brown Instrument Co., Philadelphia, Pa.

A295 **Industrial Pressure Instruments.** 40-page Bulletin 185 describes complete series of indicators, recorders, controllers, recorder-controllers, time-cycle controllers, accessories. The Foxboro Co., Foxboro, Mass.

Part I (Theory) of the A.S.M.E. Committee's Report a multiple-orifice gas-meter prover ("funnel meter") is briefly described under area meters and the text says ". . . probably the oldest form of area meter . . ." but happily adds " . . . hardly classifiable as such." In Part II (Descriptions) a manually selective multiple-orifice air meter is included in the section devoted to area meters, without reservations.

With this view the author cannot agree, being convinced that these two devices, and their like, are head meters. Reasons:

(1) The area is not *variable* in the sense described in Art. (a) and implied in the A.S.M.E.'s own definition; it is merely *adjustable*, the operator selecting an orifice area suitable for the range of the manometer, much as he would select an orifice plate of convenient size when installing an ordinary orifice meter.

(2) Flow is not indicated by the element which determines area—except in the roughest way, much as one can estimate from experience the capacity of a given size of orifice before installing it in a given size of line. On the contrary, flow is measured by reading, *on a manometer*, the differential head between upstream and downstream pressures, after taking the temperature and barometric pressure, and referring to a table.* That the "downstream pressure" is atmospheric makes no difference.

(3) The differential head is not and cannot be automatically controlled by some device in these meters as they are actually made. It is not constant and, when it is manually regulated, such regulation is not effected by regulating the orifice area: (*a*) in the multiple-hole prover the head is regulated by the operator who has to manipulate a valve upstream (said valve no part of the prover) while keeping his eye on the manometer; (*b*) in the air meter there is not even a provision for manually regulating the head after selecting orifice size—in fact a pressure recorder is a flow-measuring auxiliary—and, to quote the Committee's own Report: "Differential Head. Variable."

Types of Primary Elements. Nothing brings out Pigott's genius as a classifier better than the fact that although he made up the A.S.M.E.'s classification in 1915 before the appearance of some radically new designs, his system can still be followed. To the A.S.M.E. types,

2.31 Gate	2.33 Cone-and-disk
2.32 Orifice-and-plug	2.34 Cylinder-and-piston

the only addition now necessary is a designation to take care of what might be called a variant of the cone-and-disk, but which we prefer to call the free-float type.

"Grades." A device fully realizing the requirements of an "automatic ideal valve" is a practical impossibility, and one approximating them has to be provided with various compensating attachments. Clear-witted designers, instead of chasing the mirage of a "pure" geometric meter, have filled three definite industrial and laboratory needs and have developed three general "grades" of area meters:

(A) A gate type area meter approximating the specifications of an automatic ideal valve. Highly perfected, more complicated and more costly than one positive meter or one head meter of equivalent maximum capacity, but less expensive than a positive or head or compound or proportional meter *plus all auxiliaries* required to compensate for variations in physical properties and to insure comparable sensitivity and accuracy at all rates of flow. Obvious application: large-volume gas metering.

(B) A rugged industrial instrument, simpler and less expensive (especially as a self-contained indicator) than an industrial head meter of equivalent maximum capacity. Self-contained or remote indicators, recorders and integrators. Numerous forms of primary elements. Types: gate, cylinder, etc. (see below). Each instrument calibrated for a given fluid under given conditions, and provided with correction tables or charts.

(C) An extremely simple, relatively inexpensive "impure type" in numerous models each of which is calibrated for a given liquid (of constant specific gravity and viscosity) or for a given gas at constant pressure and density. Indicators only. Accuracy range depends on applications in view, some precision laboratory models being available.

(d) Free-Float

General Description and Characteristics

This is the simplest type (one model actually consisting of only two parts—two *pieces*) and the most versatile type: more models are to be had than models of industrial mercury-in-glass thermometers. It is used for measuring flow rates

*Possible exception to this method of use, the particular form of prover selected as type example by the Committee—the obsolete "funnel meter" illusttated on page 48 of the third edition (1931) of the Report. This "funnel meter" type of prover is no longer used for proving meters.

from 0.001 to 10,000 cu. ft. per hour (more when used as a proportional meter). Its parts can be made of practically any material, so that it is the only type of rate-of-flow meter suitable for hydrofluoric compounds.

Essentially, the type consists of two parts: a transparent vertical tube with conical or conoidal bore, in which a loose float does three things: (1) it restricts flow, (2) it produces a fixed differential and (3) it indicates by its own position the area of the annular cross-section between itself and the tube wall. (The indication of area need not be absolute, and never is in practice, since the only people interested in measuring the areas are the designers and those who make up meters by selecting tubes and floats—and the latter only have to know the big-end clearance and small-end clearance in filling an order for a specified capacity.) The density of the float must differ considerably from that of the fluid for two reasons: so that the float will not be carried along, and in order

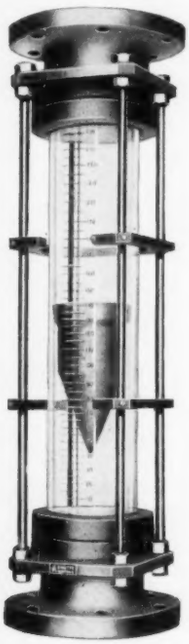

Fig. 26-4

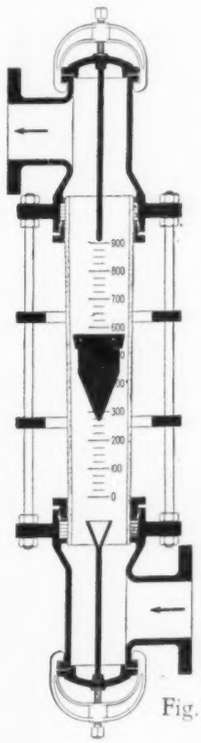

Fig. 26-5

to provide a "load" determining the constant head. Usually, flow is upward and the float is heavier than the fluid it displaces, but for metering certain liquids under exceptional conditions flow may be downward and the head determined by the buoyancy of the float. In the following, "up" and "down" will refer to normal meters.

The scale is usually etched or engraved on the glass or other transparent material. With a uniformly tapered bore, the annular orifice *width* increases in direct proportion, and its *area* in quadratic proportion, to float lift. Even with a corrective conoid, the calibration is not a straight line. One reason is that the coefficient of discharge of the annular orifice varies; the other is that in this type of meter the viscous drag is not only considerable but inversely proportional to diameter ratio. In plain words, the float gets a stronger push when it nearly fills the bore and acts as a piston, than it does when there is lots of room. These effects being additive, the flow scale of a conical-bore meter closes up in the upper end. Moreover, a bore so shaped as to make the scale uniform for one fluid will not give an exactly uniform scale for another fluid, but the error will be negligible for general practice unless the viscosity of the second fluid has a greatly different value—or unless the range of the meter extends down to less than around 10% of its capacity.

An odd characteristic of free-float meters, consequently, is that some simple models are the least expensive of all flow meters but the scales on their tubes are arbitrary (usually millimeters) and their price is nearly doubled when they are desired to be scaled in flow units—which calibration, of course, is for a specified fluid under specified conditions. Many models, however, are regularly made up for standardized applications. Example, the Airco Oxygen Flow Meter (Air Reduction Sales Co.), constructed of "a transparent synthetic plas-

A296 **Water Treating.** 12-page catalog features automatic proportioning unit for chemical feed. Dearborn Chemical Co., Chicago, Ill.

A297 **Measurement of the Electrical Conductance of Non-metallic Pipe Coatings.** 8-page reprint of paper by E. R. Shepard, E.E., Bureau of Stds. Sensitive Research Instrument Co., New York City.

A298 **Ohmite News.** October issue's technical article is on how to calculate transformer primary rheostats. Ohmite Mfg. Co., Chicago, Ill.

A299 **Thread Gages.** 4-page bulletin on specially-processed plug and ring gages. The Sheffield Machine & Tool Co., Dayton, O.

A300 **10,000 Engineers Can't Be Wrong!** is title of 4-page list of prominent users. Republic Flow Meters Co., Chicago, Ill.

A301 **Cenco News Chats.** October issue discusses uses of thermelometer, constant-temperature well, Paimer-Millikan oil-drop apparatus, etc. Central Scientific Co., Chicago, Ill.

A302 **Experimenter.** October issue signalizes vanishing of "bread-board" assemblies by featuring modern unit panel construction adapted to laboratory apparatus, public address systems, experimental transmitters and receivers, etc. General Radio Co., Cambridge, Mass.

A303 **Telephoto Attachment.** 6-page bulletin describes new mirror system. American Askania Corp., Chicago, Ill.

A304 **Microscopes.** 8-page folder D-134 describes new line of microscopes with interchangeable parts enabling user to start modestly and add as budget allows. Bausch & Lomb Optical Co., Rochester, N. Y.

A305 **Spectrographic Instruments.** Methods and instruments for spectrographic analysis are described in a 48-page booklet issued by the Bausch & Lomb Optical Co., Rochester, N. Y. This booklet is a brief textbook on the subject.

A306 **Quartz Monochromator.** Leaflet describes a new source of ultraviolet monochromatic light. Bausch & Lomb Optical Co., Rochester, N. Y.

A307 **Noise Surveys.** Mimeographed bulletins on noise levels in Buffalo, N. Y., and London, England. E. E. Free Laboratories, New York City.

A308 **Industrial Potentiometer.** Folder on "Specialized Micromax" which indicates, records, signals and controls. Leeds & Northrup Co., Philadelphia, Pa.

A309 **Aircraft Radio.** 28-page bulletin on Type 208 Aviation Communication Equipment. Western Electric Co., New York City.

A310 **Optical Instruments.** 12-page List No. 35 describes latest microscopes and accessories. J. Rosenbaum, Berlin, Germany.

A311 **Test Set.** Advance Sheet No. 3 (July '33) on Type CSO Split Core Transformer Test Set. Roller-Smith Co., New York City.

A312 **Magnetic Thickness Gage.** Loose leaves on new rapid-inspection aid. Commercial Engineering Labs., Detroit, Mich.

A313 **Fritted Glass Filters.** 24-page Catalog No. 232-LE on Jena fritted glass apparatus. Fish-Schurman Corp., New York City.

INSTRUMENTS, 330 W. 42nd St. New York City

Please have me supplied with a copy of each piece of Manufacturers' Literature listed below.

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HEADQUARTERS FOR
AUTOMOTIVE & SPECIAL
INDUSTRIAL INSTRUMENTS

Internal Combustion Engine Indicators

Easily installed, "Research" Direct Pressure Engine Indicators are used to study pressure conditions in *combustion chambers, intake systems, exhaust systems* and *supercharger* or *scavenging systems.*

The driving connections are simple and the pressure elements may be located in any convenient position.

As many as *16 diagrams* may be drawn on one chart at the same time—from 16 cylinders or from other points selected.

Railway Motor Car Recorders

Make a continuous record of *(a)* fuel consumption in miles per gallon, *(b)* speed in miles per hour, *(c)* indicated drawbar pull.

Equally suitable for power plant and marine installations, recording *(a)* engine speed, *(b)* indicated mean pressure, *(c)* fuel in gallons per hour.

Dynamometers
Fuel Measuring Apparatus
Air Flow Indicators
Magnetic Thickness Gages
Proving Stands
Pyrometers
Slow-motion Study Equipment
Slow-motion Photography
Sound & Vibration Apparatus

COMMERCIAL ENGINEERING LABORATORIES
4612 WOODWARD AVENUE
DETROIT, MICHIGAN

tic" with a conoidal bore, employing a stainless-steel ball for its float and scaled for liters per hour of dry oxygen at 70° F. and one atmosphere.

The usual range of free-float meters is down to 10% of capacity but by changing proportions it may be extended at the sacrifice of precision of readings, or shortened with consequent increase of sensitivity. The usual "accuracy" guarantee is ± 2% but this can only refer to intrinsic accuracy, not to accuracy in use: this may be better with a high-grade instrument measuring a fluid at constant temperature (no viscosity variation), and on the other hand one foreign firm asserts that in free-float meters employing a principle different from theirs "the reading may be momentarily correct or momentarily 50% out."

The capacity of a free-float meter can be changed readily by removing the float and inserting one of different diameter or weight. This is advantageous when one instrument is to be used to check flows here and there. "In one case the total flow range obtained was 200:1" states an American firm.

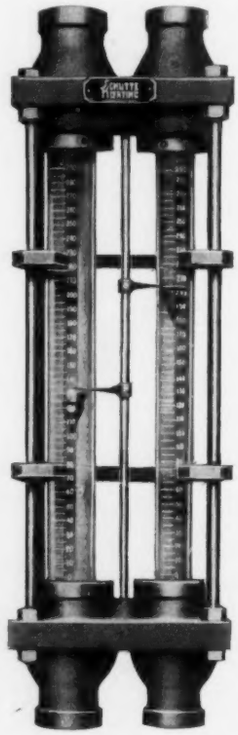


Fig. 26-6

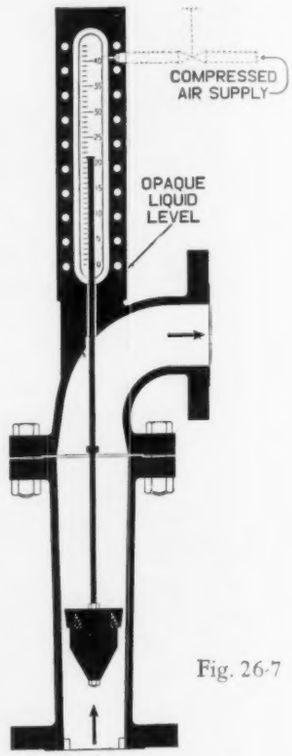


Fig. 26-7

Commercially Available Models

At present the widest variety is found in "Rotameters," so called because the float is a top-shaped rotor with spiral slots which, as the fluid flows by, cause it to spin, keeping it in the center of the stream and preventing errors due to friction against tube wall. In addition (though this is not mentioned in the Rotameter descriptive literature) the gyroscopic effect undoubtedly serves to steady the rotor when flow is slightly fluctuating.

Schutte & Koerting Co.'s Rotameters—These are regularly supplied with millimeter scales. When specified, calibration is furnished as a curve sheet plotting flow (of a given fluid under specified conditions) against millimeters lift. Fig. 26-4 shows the style most widely used in industrial plants. It is made in 12 sizes from ¼" to 4" connections with 0.33 to 175 g.p.m. maximum water capacities. Fig. 26-5 shows a style made in the same sizes for horizontal line applications and where ease of tube cleaning or change of rotor is desired. Fig. 26-6 shows a twin style for fuel-and-air and other ratio applications, which is standard equipment on some General Electric Company gas furnaces. Fig. 26-7 shows a style made in 18 sizes (0.33 to 1800 g.p.m. max. water rate) for measuring flow of opaque liquids by means of an air-pocket sight-chamber. The rotor not being *entirely* free, this style really belongs under the cone-and-disk type. So does the Rotameter in Fig. 26-8, a schematic diagram of an installation for obtaining remote indication, recording and totalizing, described by Schutte & Koerting as follows:

The rotor position locator is essentially an a.c. induction coil. An iron rod, hung onto the rotor, projects into a closed well placed below the tapered metering tube. The rod is not attached to anything except the rotor. It can be coated with any desired corrosion-resistant material depending on the service. Wrapped around the outside of the well is

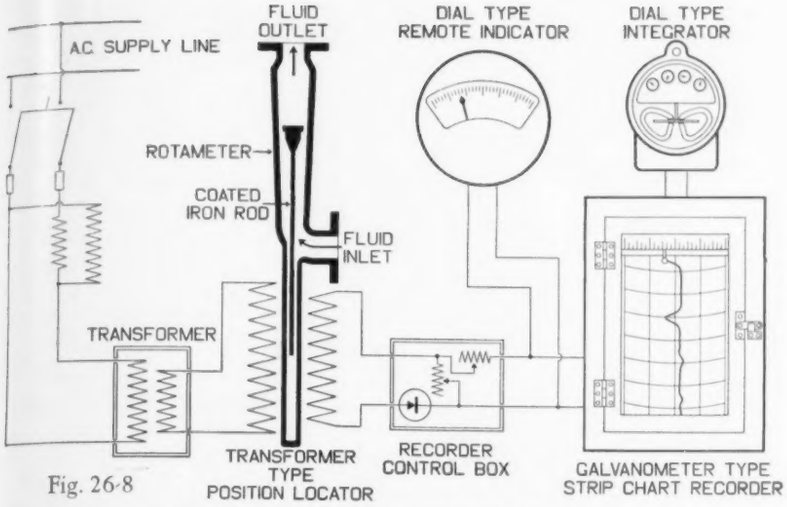


Fig. 26-8

an induction coil. An a.c. current is passed through the primary winding and induces a current in the secondary winding. Changes in vertical position of the iron rod change the voltage induced in the secondary winding.

The recording instrument is essentially a millivoltmeter which measures the voltage induced in the secondary coil circuit. The control box contains a transformer, a rectifier, a sensitivity adjuster, a voltage regulator and a zero-setting regulator. The entire system can be plugged directly into a 60 cycle a.c. supply line.

Rota Werke—This German manufacturer's literature describes an astonishingly wide variety of models, five of which are shown in Fig. 26-9. Note the use of Rotameters as proportional meters for lines in any direction, making it possible to measure downward flows with big-end-up tubes. "B-9" is a model for high-pressure liquid ammonia and SO_2, with automatic safety shut-off.

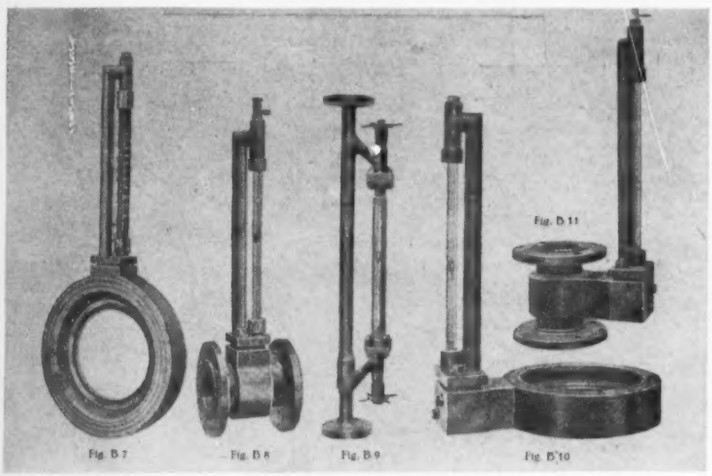


Fig. 26-9

(e) Gate

A gate valve, which should be carefully machined, is the primary element in meters of this type which fall into two distinct sub-types: (2.31-M) depending on manual operation for constant head; (2.31-A) automatic.

Manually Operated

These gate meters can only be used on steady flows. We may again divide them into two kinds: (1) Modified steam or water valves; (2) Specially designed metering valves. Example of the first kind, the "Sentinel,"a British valve company's standard product with position indicator, the only essential addition being a differential pressure gage connected to the inlet and outlet. Extracts from description by Alley McLellan, Ltd.:

"As meters, the valves . . . will measure from quite a small dribble up to the full amount the pipe will carry. . . . Anyone can take readings accurate well within commercial requirements. For instance, the 6" valve towards one end of its range plainly indicates the difference between 500 and 501 gallons of water per minute, and all valves will measure rates of flow smaller than 1 per cent. of their maximum capacity."*

*The last two sentences seem disingenuous: a statement pertaining to *accuracy* is immediately followed by a claim of 0.2% *sensitivity* and by another on *measuring* small flows, giving the impression of a 0.2% limit of error. In all likelihood, the average error of one of these meters is at least 10% when the measured rate is 1% of capacity—not counting parallax and other errors of pointer-and-scale position indicator as actually made.

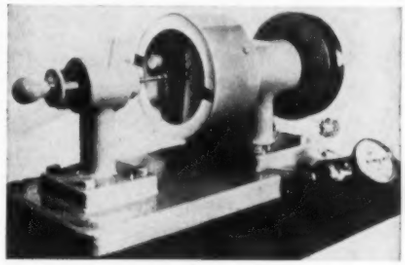
NEW INSTRUMENTS

Write Information Section, Instruments Publishing Company, for additional information.

Torsion Impact Tester

Baldwin-Southwark Corp.

A MOMENTUM unit, and a head for holding the specimen, are rigidly bolted to a bed plate. The momentum unit consists of a pair of balanced flywheels. One flywheel carries on its outer face two symmetrical striking bosses. The flywheels may be rotated by means of the counter-balanced handle. The head is a holder sleeve having a



square hole into which one end of the specimen is clamped. To the opposite end of the specimen is attached the crossarm having a square hole into which the other end of the specimen is secured. The holder sleeve can be slid axially in the housing but is prevented from rotating. *Operation*: The specimen is clamped in the holder sleeve, with the crossarm properly attached. The knob is pulled entirely back so that the crossarm entirely clears the bosses. The flywheels are then rotated to a predetermined speed measured by a portable tachometer. The knob is then pushed sharply inward, bringing the crossarm into engagement with the bosses on the rotating wheel, and the specimen is thus broken under torsion impact. The residual speed of the wheel is then read, and the energy absorbed in breaking the specimen is obtained from a prepared table. One operator only is required, and the entire operation of mounting and breaking the specimen and obtaining the result requires only about two minutes. A guard prevents the crossarm from flying after the specimen is broken. Another guard is swung over the middle portion during testing to prevent the flying of fragments.

◆ ◆ ◆

Adjustable-timing Contactor

Automatic Temperature Control Co.

FOR industrial service a new design of timing contactor, known as Type 1290, sturdy in construction, has a minimum number of parts, will operate in any position without the need of leveling and is unaffected by vibration. The elapsed time can be set to less than a scale division for any range desired within the dial selected. Power is obtained from a reversing synchronous motor and the contact arm moves alternately clockwise and counter-clockwise within the time limit set, making a 10-amp. 110-

volt a.c. load circuit for an adjustable time at either extreme of its travel. Timing contactors of this new design are also available to be actuated from a momentary contact switch, run for the time cycle for which they have been adjusted and stop until the starting switch is again energized. These "cycle stop" type contactors make and hold their load circuit at the expiration of the time set, or they may be supplied to make the load circuit at start of the time cycle and break it when the time set has elapsed.

◆ ◆ ◆

Prepayment Watthour Meter

Sangamo Electric Co.

ALTHOUGH the Type HCP is announced as a new product, its component parts have all been used here or abroad in manufacturing quantities. Built in all single-phase capacities from 5 to 25 amp., both 2- and 3-wire, it is designed for applications presenting a collection problem: resorts, tourist camps, apartments where accounts are delinquent, etc. Base, case and coin box are all cast aluminum. Meter parts (except series coil and cutaway register) are identical with those of maker's HC meters. Coin mechanism is arranged for the U. S. quarter. Change gears permit securing any rate from 3c to 15c in ½c steps. Total of money inserted is registered on upper three circles, while *unused* kwh's are indicated on single circle at upper center. Coins can be inserted until this circle indicates 100 *unused* kwh's. *Used* kwh's are registered on the customary 4-circle register. By disconnecting the switch leads the complete coin mechanism can be removed as a complete unit without disturbing the rest of the meter.

◆ ◆ ◆

Oil Combustion Indicator

Ess Instrument Co.

IN oil-fired equipment it has recently been found that optimum combustion efficiency is obtained at what is known as the "haze point." This latest addition to the "Smokgage" line of photoelectric smoke-density indicators and recorders

"The manometer consists of a plunger, which is a free but practically fluid-tight fit in its cylinder. Pressure is led to its under side from the inlet, and from the outlet pressure is led to the top side. When the standard pressure difference is reached, the plunger floats, and this movement is easily seen through the glass tube. The friction is negligible."

The second kind, designed especially for metering purposes, includes the infinitely adjustable orifice devices of head meters. Two of these were described in detail in Chap. XXV, **§10.** Inspection of Figs. 25-53 and 25-54 shows that the American Meter and the Bailey devices are provided with carefully located meter connections—for the usual recording and integrating instruments of head meters with which they are regularly used. In some instances, as when the instrument needs adjustment, it is a simple matter to connect a U-gage in its stead. The combination then will be either a head meter or an area meter, depending entirely on how it is used: if the operator keeps the head constant and reads flow on the gate position scale, it is an area meter.

Automatic Gate Meters

In this age of automaticity, with thousands of different contactors, relays, pilot valves, etc., it is amazing that so few automatic gate type area meters are available. Two general principles (corresponding exactly to the main division of the whole field of automatic control—see Part One) may be employed:

(1) *Self-operating*—Upstream and downstream pressures act directly on the two sides of a loaded piston which directly operates the gate.

(2) *Relay (or "Motorized")*—The differential gage makes electric contacts or actuates a pilot or relay and thus constitutes the primary element of a con-

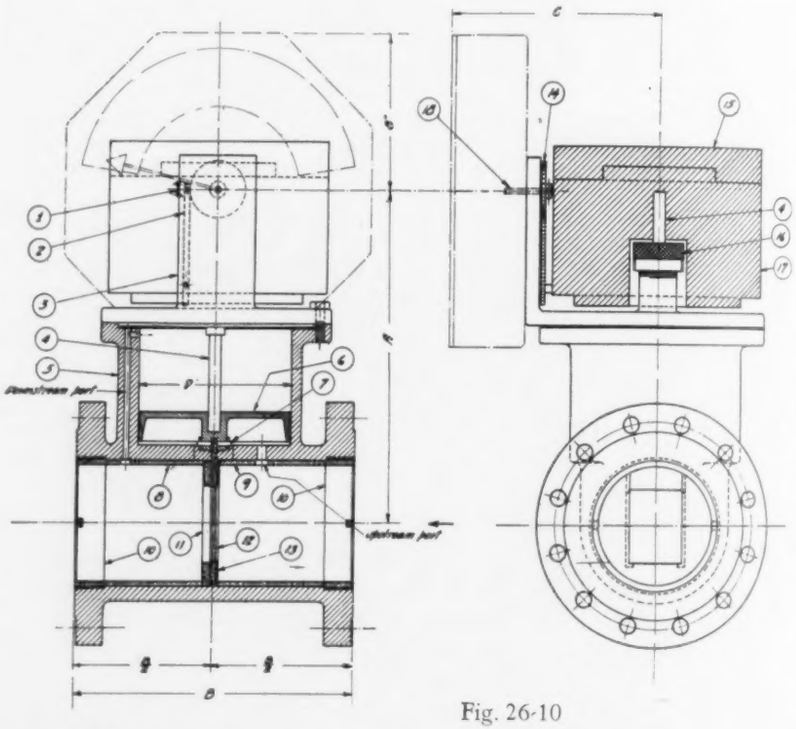


Fig. 26-10

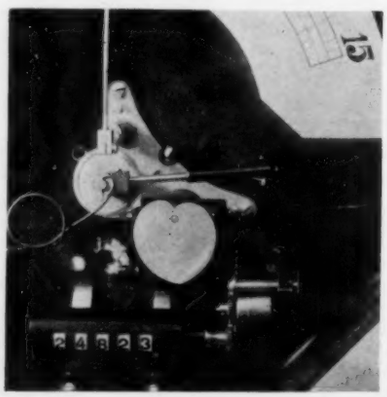


Fig. 26-11

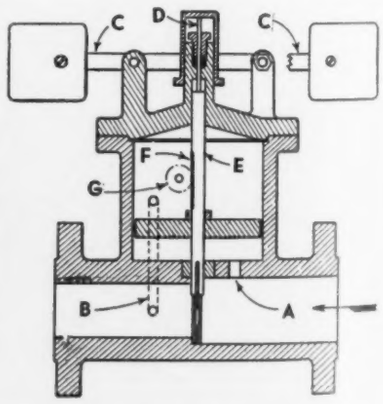


Fig. 26-12

trol system, the final or "power" element of which operates the gate. The system may be electric, pneumatic, hydraulic, steam-powered, or combination.

Each of these two principles has inherent advantages and shortcomings (see Chap. III) which may here be summarized by the statement that whereas a self-operating device can only be *set*, a control system can additionally be provided with any number of *adjustments*, either manual or automatic.

Specifically and briefly, a self-operating gate meter has the advantage of simplicity but the only "adjustment" (in control technology meaning) is of the load on the piston, which determines the differential to be maintained constant; a relay or "instrument type" system can have its "mode of control" altered to suit the application and eliminate "hunting" and in addition it may include elements responding to variations in the physical properties of the metered fluid. As it happens, however, there are only two automatic gate meters (both made in U.S.A.) and the self-operating is a relatively small one (12″ max. pipe) for high pressures and high differentials, while the motorized one is for metering large volumes of gas with a small pressure drop. The foregoing analysis is not meant to draw invidious comparisons.

The automatic gate meter utilizing the self-operating principle is the *Isometer* (Isometer Co.) which is made in two distinct models. Fig. 26-10 shows the "Type A" with directly-weighted piston for flow applications where fixed pressure loss of either 120 or 240″ of water is permissible; Fig. 26-12 is a schematic drawing of the lever type of Isometer in which the constant head need not be so considerable.

The "Type A" Isometer is available for electric remote indications, recording and totalizing, in fourteen combinations. Fig. 26-10 shows a non-electrical model with a directly-mounted indicating and integrating instrument shown in dotted lines, the solid lines showing only the "actuator." This consists of a horizontal flanged section with liner, in the center of which is fastened a set of plates (of Nitralloy, stainless steel, etc.) forming a rectangular orifice. The tongue (12) is machined from the same material. The cylinder, forming an integral part of the actuator, contains piston 6 which positions itself so that the difference between the upstream and downstream pressures on its two sides equals the constant load. "The power operating the Isometer is about ten times that obtained from the floats used in the usual mercury flow meters . . . accuracy range of from 2% of capacity to full capacity." Fig. 26-11 shows details of one of the Isometer instruments, equipped with "what is probably the simplest integrator built." A cam driven at constant speed by a synchronous motor raises and lowers a contact arm at regular frequency. Duration of contact depends on position of indicating pointer, hence increments on counter are proportional to rate of flow.

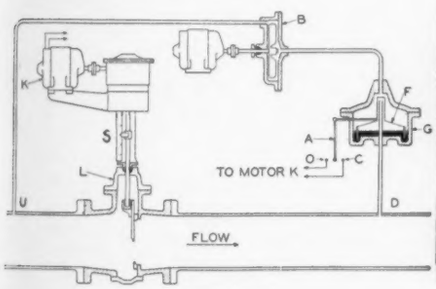


Fig. 26-13

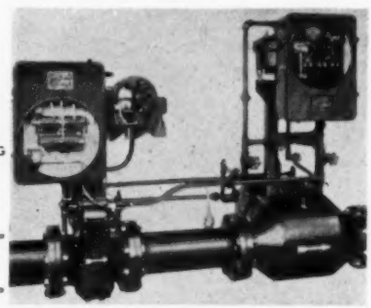


Fig. 26-14

The automatic gate meter utilizing the relay control system principle is the *Linderman Meter* (American Meter Co.), designed especially for accurate gas measurement where load varies considerably (as in industrial loads) and where total consumption is to be expressed in standard cubic feet regardless of variations in temperature, pressure, specific gravity or rate of flow. Fig. 26-13 is a schematic diagram showing the essentials: (1) Differential is measured by a bell float manometer provided with electric contacts whereby the motorized valve is operated. (2) The "setting point" of this differential controller is automatically varied by a *density* element consisting of a constant-speed blower. (The differential produced by a constant speed blower is directly proportional to the instantaneous density of the gas—which depends on its temperature, pressure and specific gravity.) These elements are so adjusted that the orifice differential and blower differential are opposed, so that the differential gage "reads zero" and that the *average speed* of the gas over the area of the variable

is therefore equipped with an electrical instrument having a Ringelmann scale (same as previous models) and also with two signal lights. The red light flashes when insufficiency of air produces smoke; the green light indicates excess air producing too clear stack gases.

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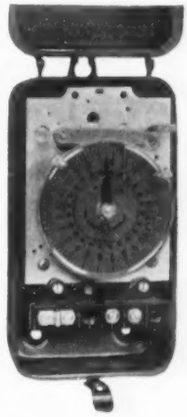
Automatic Time Switch

General Electric Co.

AS a companion switch to the Type T-13 general-purpose automatic switch, Type T-15 has been brought out for indoor service. It has no cover gasket, is finished in black lacquer, and is with or without a window in the case; in other respects it is identical in time and switching mechanism design with the Type T-13. The new 30-amp. switch is available in 12 forms—with or without a device for skipping operation on certain days, for either 115 or 230 volts, and for single-pole, single- or double-throw, or double-pole, single throw. Overall case measurements are 10-2/32″ height, 5⅜″ width and 4-13/16″ depth. The switch weighs 6½ lbs.



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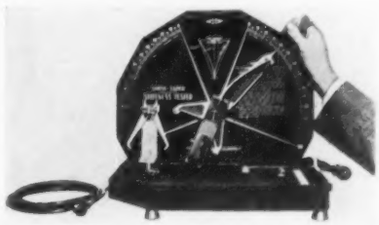
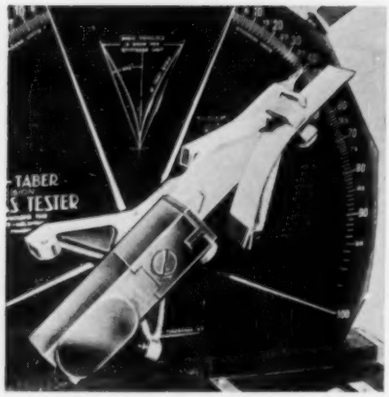
Stiffness and Resiliency Tester

Smith-Taber Research Engrs.

VARIOUS tests which heretofore have been either impracticable or inconclusive are said to be made possible by means of this new instrument, opening up new fields of investi-





gations and standardizations. Pending official promulgation, the research organization which has developed the instrument has proposed tentative procedures, definitions, etc. The principles involved in the proposed quantitative determinations, are simple; the apparatus is designed and constructed to minimize the personal equation. Among other features are built-in means for shearing light materials into uniform specimens, signal lights for end point, etc. Results from two or more instruments under similar test conditions should be exactly alike, it is said. Our illustration shows the "ultrasensitive attachment" in use for testing such pliable materials as metal foil, cellophane, fabric, etc. Specimens are held differently for making "Initial Stiffness" and "Basic Stiffness" tests.

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Profile Projector

The R. Y. Ferner Co.

INTRODUCED by the Société Genevoise d'Instruments de Physique, of Geneva, this equipment differs from the usual projection apparatus in that the image is projected from below onto a heavy glass screen set in the top of a steel cabinet at a convenient angle for examination or measurement. There is no interference from shadows of the operator's head or hands or the rules or templates he uses. It therefore can be used for tracing the design of small articles of which no drawing is available, or to photograph the profile. Special accessories and supports make it possible to examine a wide variety of articles, not only small parts of instruments, watches, typewriters, etc., but pieces made of material subject to deformation when measured mechanically, textile fabrics, wire sieves, etc.; or to check holes in perforated metal used for sizing purposes. Among accessories are a table for making measurements in rectangular co-

orifice is always 8400 ft. per min. The result is measurement of gas quantity at line conditions. This quantity is then simultaneously multiplied by factors for line temperature and pressure by means of an integrating mechanism with three cylindrical cams. This type of integrator was described in Chap. XXIII, §10, Art. **(i)**.

Fig. 26-14 is a general view of a 6" Linderman Meter installation. Note that the blower is located in a special casting which forms a section of the pipe line. This is in order to prevent variations in blower differential due to external causes: the blower is placed in the stream of flowing gas. Constant speed is obtained by synchronous motor drive from outside the pipe. Continuous sampling is assured by means of a small fixed leak, the gas returning to the main. The variable orifice is the American Meter Co.'s "infinitely adjustable" device described in Chap. XXV, motorized.

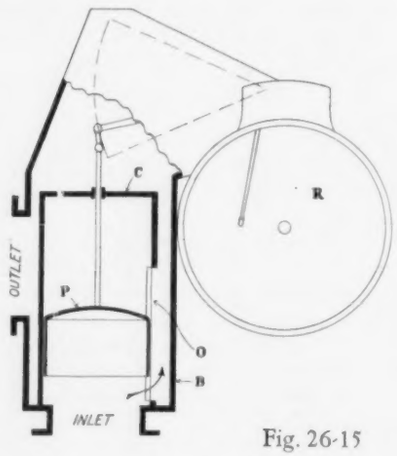

Fig. 26-15

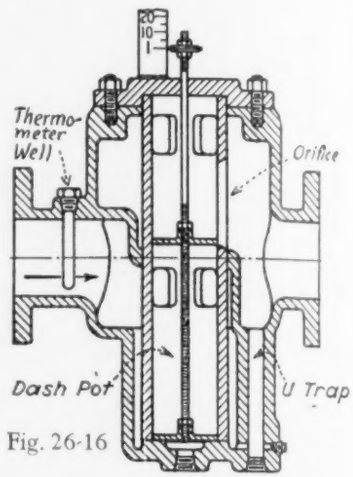

Fig. 26-16

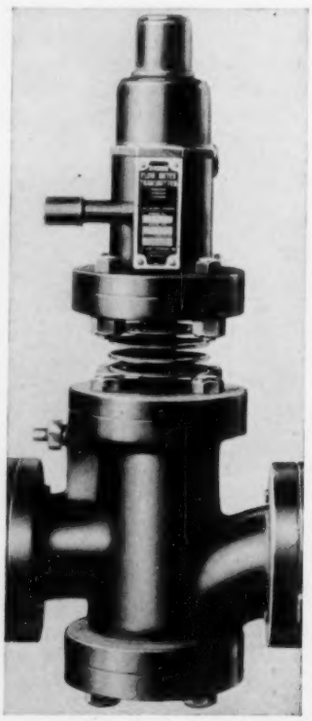

Fig. 26-17

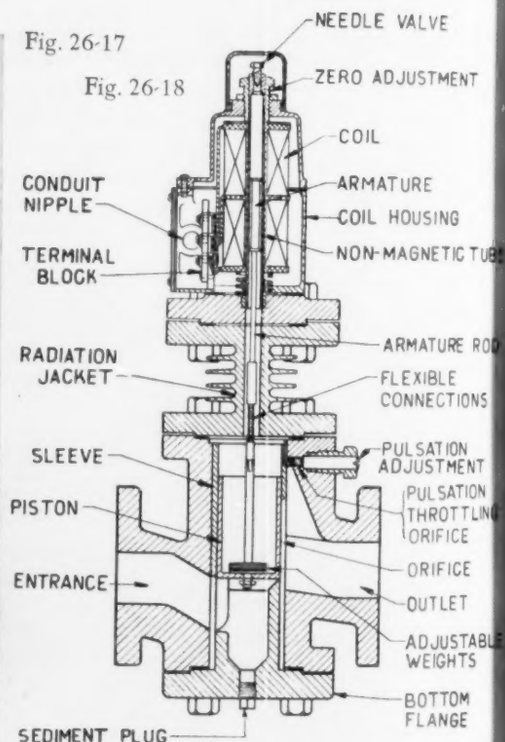

Fig. 26-18

(f) Cylinder-and-Piston

Much of the foregoing discussion of the free-float and gate types applies also to the cylinder-and-piston type of area meter, which consists essentially of a cylinder with one or more slots or holes providing a total area of which a portion varying from zero to full area is opened by a piston acted upon by two forces: the upstream pressure on the bottom, and on top the downstream pressure plus a constant load. The principle is apparent from Fig. 26-15 which is

our rough schematic diagram of the *Lambert Recording Demand Flowmeter* (Lambert Meter Co.) which is designed for gas work and has a fixed pressure drop of less than 0.3″ water. The cylindrical portion of the body B contains a cylinder C in which piston P positions itself to determine the area of the longitudinal-slot orifice O through which the flow will create a differential balancing the piston. As actually made, the meter outlet is in back and the orifice is in front, visible through a glazed window so that at any time the piston lift may be compared with the position of the recorder pen on the chart scale, which is uniform for ease of planimetering. This meter is made in hourly capacities from 2500 to 20,000 cu. ft.

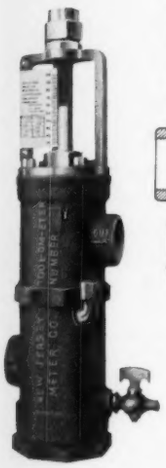

Fig. 26-18

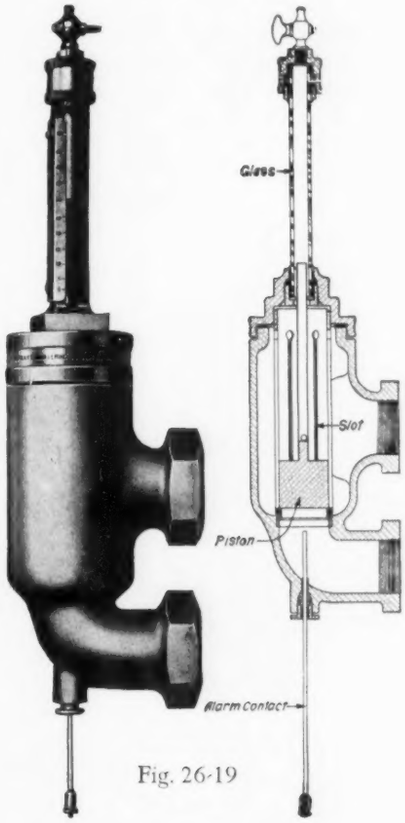

Fig. 26-19

Fig. 26-16 shows the Ingersoll-Rand *Air Meter* which not only has a similar longitudinal slot but also large ports to take care of excessive flows beyond those measured on the uniform scale. Standard application, condenser tests.

Fig. 26-17 is an outside view and Fig. 26-18 a sectional drawing of the *Brown Area Meter* (Brown Instrument Co.) which was designed primarily for heavy oils, chemicals, etc., the metering of which is somewhat troublesome when head meters are used. The moving elements are completely enclosed and the position of the piston is transmitted electrically to remote indicating, recording or integrating elements. Scales are uniform. Sizes are made in maximum hourly capacities from 150 to 2000 gallons of water, all in one pipe size (2″) at the date of writing. The range is adjusted by adding or subtracting weights in the piston cup and installing a different size orifice sleeve. The 5 sq. in. piston area permits operating at a relatively low pressure drop without "sticking." Depending on the application, the body is furnished with either a steam jacket or a finned radiation jacket.

The "*Tool-om-eter*" and "*Drill-om-eter*" (New Jersey Meter Co.), especially designed for compressed air users, are frequently used to measure consumption of air-operated machines. The sectional drawing, Fig. 26-18 is self-explanatory. Note the dash-pot for damping fluctuations of the indicating element on pulsating flows. Damping should not be complete: a small visible vibration is evidence that there is no sticking and hence no serious error of flow measurement. Late models are said to be so compensated that they do not read high on pulsating flows encountered in practice. The 1″ "Tool-om-eter" is scaled 10 to 100 cu. ft.; the 2″ "Drill-om-eter" 50 to 300 cu. ft. per minute of air at 60° F. and atmospheric pressure, the calibration being for air at 80-lb gage pressure

ordinates, an adjustable protractor sliding along a guiding ruler for use in drawing, glass scales, a magnifying glass mounted on rubber feet, etc. Four objectives give magnifications on the screen of 10X, 20X, 50X and 100X, so free from distortion that the shadow is accurate to 1/2000th. A green filter avoids fatigue. The object table is a 2⅜″ round glass plate adjustably mounted approx. 5″ *above* the surface of the screen and just behind it, so that the operator can rest his elbows on the cabinet while making adjustments. Two columns and a steel frame for supporting a black curtain make possible the use of the instrument in daylight. Photographs are possible by the use of an adapter and plate holder surrounded by a black cloth. The useful area of the glass screen is 12½″x15¾″ so that with the 100-power objective the maximum size of object is ⅛″x5/32″. Articles up to 1¼″x1-9/16″ may be projected with the 10-power objective.

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Portable Combustion Test Set

The Hays Corp.

SIMILAR on the whole to the makers' previous sets, the new "Series 3000" embodies refinements and is modernized. It is enclosed in a green-lacquered spot-welded corrosion-resistant steel case with leather carrying handle and weighs but 9 lbs. The Orsat is the Hays Engineer's Model, range 0 to 21%, of which 30,000 are said to be in use; the draft gage is of the dry type (*Instruments*, Feb. 1933, page 44) in either of two ranges: +0.1″ to −0.4″ or 0 to −1″. A 5″ long flue gas thermometer, range 200 to 800° F., is optional. It may be clamped inside the set or carried in one's pocket.

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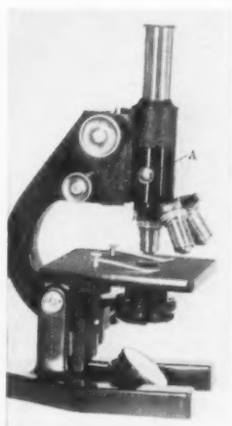
Five Microscopes in One

Bausch & Lomb Optical Co.

MINDFULNESS of the fact that users cannot always purchase at once the ultimate microscope they desire has led to the design of a new series of instruments, any one of which may be added to from time to time as the user's budget permits. Body tubes, mechanical stages, condensers, eyepieces and objectives are interchangeable. The basic model "HS" is illustrated. A quarter-turn of button "A" loosens a ring clamp which holds the upper part of the body tube rigidly in place. Special attention has been paid to durability of parts. The working distance between the arm and the optical axis is 98 mm. The stage is 130 mm. long and 115 mm. wide, as compared to the usual 112 mm. square. The side fine adjustment has been improved so that it



is sensitive, wear resistant, exceedingly slow in action, and functions without lubrication. One drum is graduated to determine the approximate thickness of specimens. Dozens of combinations are possible but the maker describes five which are distinctive enough to constitute five different microscopes.

There is also announced for the first time a "revolutionary new condenser for laboratory microscopes," having features supplied heretofore only on the maker's finest research microscope. It is of the Abbe type 1.20 N.A. Its feature is a supplementary lens in a *swing-out* mount, to fill the field of a low power objective. An iris diaphragm, blue glass disk and dark field stop are included with each condenser.

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Industrial Dial and Recording Thermometers

Jas. P. Marsh Corp.

SUPPLEMENTING their line of pressure gages, the makers are announcing temperature instruments with two types of thermal systems: "The bulb, connecting tube and Bourdon spring are filled with vapor or gas which expands and contracts to temperature changes." *Vapor-pressure* system dials or recorders are available in ranges up to 500° F. or equiv. C. with progressive scales. *Gas-filled* system dial thermometers are available in ranges up to 800° F. or equiv. C. withuniform scales; recorders up to 1000° F. Several sizes of bulbs are available, with several forms of connections. Standard dial size is 5", standard recorder chart size is 8". All cases are dust- and moisture-proof with black enamel (standard) or other finish. Dial thermometers may be obtained either in distance or in self-contained styles with bulb at bottom (illustrated) or in back; recorders come only in distance style.

above standard atmosphere, at the meter. Correction tables are supplied for other conditions.

The *Vaughan Liquid Meter* (Spraco, Inc.), Fig. 26-19, employs a slotted cylinder and a glass-enclosed indicator. It is made in various sizes with maximum capacities of 10 to 100 g.p.m.

In all of the cylinder-and-piston meters described above, there is a slight leak past the piston, which—since the head is constant—should remain constant throughout the lift, provided that the cylinder bore is true. It has the effect of "suppressing zero" on the flow scale. At flows above 2 to 10% of capacity, depending on precision of manufacturing, etc., it is not a source of error, being taken into account in calibrating.

(g) Cone-and-Disk

The principle employed in this type is similar to that of the free-float, so that much of the discussion in Art. **(e)** applies, but most cone-and-disk meters manufactured are steam flow recorders, with precisely machined conoidal tubes. The disks, too, have carefully shaped edges. Meters of this type do not seem to have made much headway in American plants. Fig. 26-21 shows the *Drayton* (English) and Fig. 26-22 the *Claasen* (German).

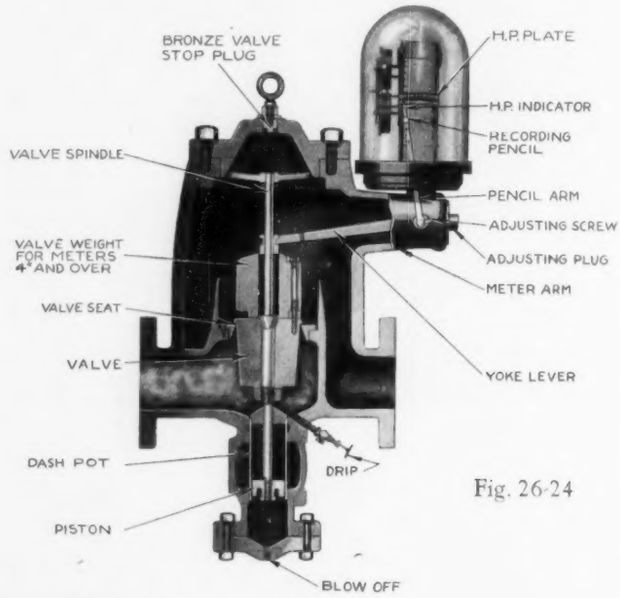

Fig. 26-24

(h) Orifice-and-Plug

A variable-area annular orifice is obtained in this type between a conoidal plug and a thin-edged seat with beveled upstream (lower) edge, the discharge coefficient thus varying little. Proper plug contour provides linear proportionality of plug lift to steam flow over nearly the entire range. Figs. 26-24 and 26-25 show the *St. John Steam Flow Meter* (American District Steam Co.), made only in recording style, of which thousands are in use in this country by companies that sell steam; also in industrial plants. The chart is unusual, consisting of a paper roll about 2½" wide with time graduations (½" = 1 hr.) on the edges, and a base line for zero flow. With each meter the makers furnish a constant, which is the hourly rate of saturated steam at 100-lb gage per inch of pencil travel away from base line; also correction tables. Planimetering and computations are thus made easy.

"It is seldom that we find a book we can so heartily recommend . . . Must be read to be appreciated."—*Heating and Ventilating*

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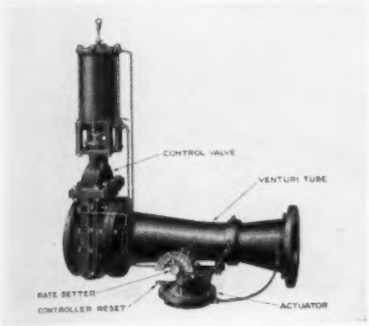
Rate-of-flow Controllers

International Filter Co.

THESE new "CD" Rate-of-flow Controllers are designed for applications where automatic maintenance of a uniform rate of flow of fluid is either desirable or necessary for efficient operation. The operating principle is the maintenance of a constant differential across the actuator diaphragm at equilibrium position, no matter at what rate the controller is set. This principle permits placing all the actual controlling elements inside the actuator casing and eliminates



stuffing boxes, pivoted levers and movable counterweights from both the line of automatic control and released power. Operating rates are changed by turning a knob and moving a pointer over a calibrated rate setting dial. The controllers are provided with a reset to close the control valve automatically when flow through the line is shut off. Thus, when flow begins, the controller regulates "up to" rather than "down to" the set rate and it is said that the normal operating rate cannot be exceeded even momentarily while the shut-off valve is being opened. To prevent waste as well as dangerous wash rates in filter plant operation, a patented automatic feature regulates the movement and position of the control valve when a wash water valve is closed. The control gate or vanes are automatically brought to a point of closure somewhat under the normal open position and are held there by the operating mechanism and the valve stop until the wash water valve is fully opened. There is but one adjustment to make after installation, for the zero or equilibrium position of the diaphragm and the control pilot. Skilled attention is never required, it is said. Controllers are shipped assembled and installation consists of setting the controller in the line and making pressure and waste connections to the pilot. Loss of head through the standard controllers is but a fraction of a foot at normal flow.

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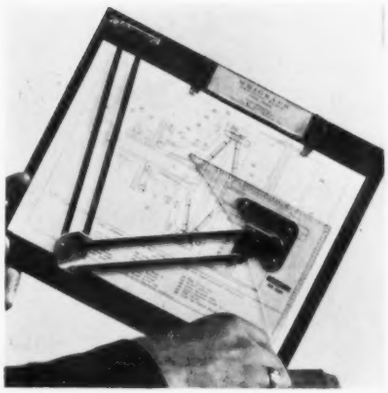
"Wrigraph" Draft Block

Fletcher F. Milligan Co.

COMBINING a drawing board and a drafting machine, this new instrument is made in three sizes. The photograph shows the "Junior" size (10"x12" board) which can be carried in a brief case for convenient use in the field or on the train, as well as in the office and home. The "Model B" has a



12x18" board; the "Model A" has an 18x24" board. The board is made of $\frac{3}{16}$" Masonite and is equipped with clips which hold either a single sheet or a pad of paper. No thumb tacks are required. The parallel device is made of heavy nickel-plated arms, connector and wrist plates, all accurately reamed and assembled with Tobin bronze bearings. Either of two drawing attachments is provided with the "Junior" model; both with the larger models. With the triangle attachment shown, angles of 15, 30, 45, 60, and 90° can be accurately drawn and other angles can be approximated. The right-angle sides are graduated to $\frac{1}{8}$" or 1/10". The other drawing attachment (a protractor and a graduated straight edge which can be set by degrees to any angle required) is particularly suited to surveying, aerial navigation, etc.

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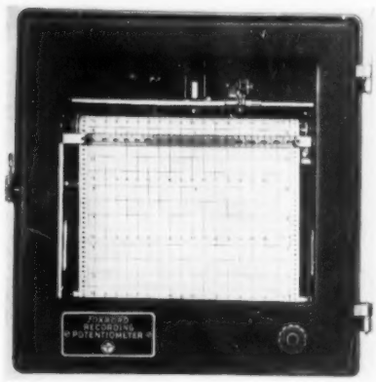
Recording Pyrometer

The Foxboro Co.

A NOVEL balancing mechanism is one of the features of this new recording potentiometer pyrometer. It is so designed that it produces a large movement of the pen or print wheel for a small galvanometer deflection. It is claimed that this results in rapid frequency of records, long wearing mechanism, and open, easily-read chart scale. The balancing mechanism consists essentially of a V-shaped drive cam and a friction roller. The sensing fingers, which detect galvanometer deflection, position the friction roller according to the position of the galvanometer pointer. The V-shaped drive cam then engages and rotates the roller, which in turn transmits its straight-line motion to the slide-wire contact, moving it a corresponding distance. The pen or print wheel, being mounted integrally with the slide-wire contact, moves with it, thus making the record coincide accurately with the measurement. The recorder is housed in a new fume-tight and dust-proof case with large glazed door making chart and mechanism highly visible. The entire mechanism can be swung forward out of the case, making every part accessible for inspection. The drive motor, mounted in rubber bushings which silence it and prevent transmission of vibration to the instrument, is completely enclosed, runs in ball bearings, has a centrifugal starting switch, and has no brushes. In the single-record instrument, the automatic balancing action occurs every five seconds, with pen movements accordingly. In the multiple record pyrometer, the printing mechanism is mounted on the top front and each record is identified by a color. The printing styles of the rotating print wheel are inked by colored-ink rollers and print the record on the upper surface of the chart paper. The record dots are square (a distinguishing feature) and large enough (approx. 0.5% of scale range) for the colors to be easily recognized. Accuracy is said to be 0.25% of scale range, so that the true value in



each successive measurement lies within the width of the dot recording this measurement. Just below the upper chart roller, the chart passes under a scale plate of transparent, unbreakable material with the scale graduations engraved on it. The connection compartment, sealed from the interior of the case and accessible from the outside, allows thermocouple and motor connections to be made or inspected without opening the main compartment containing the mechanism.

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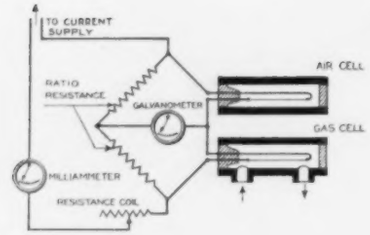
The Currier Size Tester

Sorg Paper Co.

NO less than 40 methods have been proposed for testing paper for degree of sizing. It is generally conceded that distilled water is the logical wetting liquid. This new instrument employs it for the standardized test, but for special problems involving various liquids, the particular liquid under study may be applied to the particular paper or sizing under test. Essentially, the instrument is a sensitive conductance meter. One terminal is a horizontal metal plate normally dry; the other is a moistened round felt approx. 1 in.^{2} in area. The plate is kept at constant temperature by a built-in thermostat. The felt is kept saturated by forming the closure of an inverted bottle. Before each series of tests (or merely once a day) calibration is verified by zeroing and by adjusting a rheostat, to make the indicator read 0 when terminals are separated and full-scale when felt is brought into contact with plate. Test consists of timing elapsed time from moment moist felt is applied to upper surface of sample to "end point" when a definite amount of liquid has passed through sample as indicated on scale.



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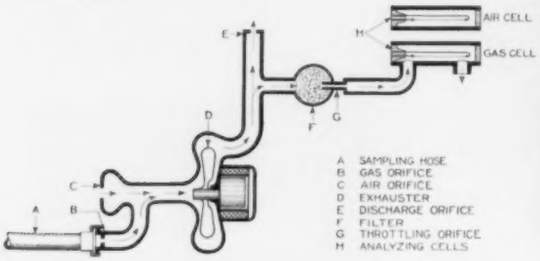

Fig. 2

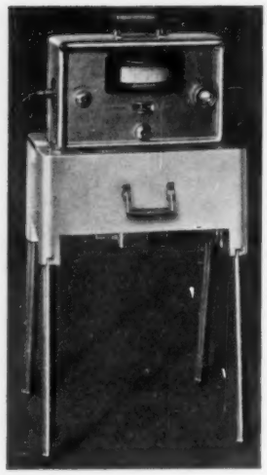

Fig. 3

Combustible Gas Analyzer

Bacharach Industrial Instrument Co.

FOR continuously measuring the combustible components of gas mixtures, this new "Model RZA" instrument employs the catalytic combustion principle and the resistance bridge method. A continuous sample is passed at a constant velocity through a cell containing an electrically heated platinum wire. The combustible constituents are burned along this wire, raising its temperature and making its resistance greater than that of an identical wire in a sealed comparison cell containing air. Fig. 1 shows the bridge circuit whereby percent of combustible gases is read off on the calibrated scale of a galvanometer. Fig. 2 is a schematic diagram of the mechanical arrangement whereby the continuous sample is (1) mixed with enough air to support complete combustion, (2) cleaned, (3) slightly compressed and (4) drawn through a flow-regulating orifice before being admitted to the combustion cell. Fig. 3 is a general view of the portable RZA Combustible Gas Analyzer, which can be separated into two assemblies, each provided with a carrying handle (another type is designed for permanent installation). The instrument operates from any 110- or 220-volt outlet and comes with all accessories required to make it ready-to-use. Binding posts afford means of connecting (*a*) a recorder, (*b*) an auxiliary indicator or (*c*) a contacting or signaling galvanometer.

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Radiation Pyrometer

Industrial Pyrometer Co.

EASE of setting up is a characteristic of this newly introduced telescopic type of radiation pyrometer, known as the "K&S Aestometer." The furnace opening or other object is focused through an adjustable eyepiece upon the thermocouple in the center of the field of view. The distance factor is 14, so that for a hot object 2 ft. across, the instrument need not be located closer than 28 ft. from it. Time lag (from "cold" until full reading is obtained) is 5 to 7 secs. Cold-junction temperature compensation is provided, and accuracy is said to be 1% of scale range. Seven Fahrenheit scales are available on millivoltmeters, from 1100-2200 to 1800-4400; also Centigrade scales. Telescope type receiver is < 7″ long and whole outfit almost as easily portable as an optical pyrometer, with the advantage that continuous readings are obtainable.

Amplifier for Oscillograph

Allen B. DuMont Labs.

TO extend the range of the cathode-ray oscillograph a "special high quality" a.-c. operated amplifier has been developed, which may be used for the measurement or observation of many effects which of themselves are not of sufficient magnitude to operate the cathode-ray tube directly and which "should not be entrusted to an ordinary amplifier" for their faithful reproduction. It may also be used for many laboratory problems not connected with the cathode-ray oscillograph. This Type 136 amplifier is a 3-stage unit with power supply which has a voltage amplification of 500 and will deliver 50 volts r.m.s. to the cathode-ray tube. The input impedance is one megohm and the output impedance is 7000 ohms resistive. It is said that the ratio of output to input voltages does not vary more than 3% from the 1000-cycle value between 10 and 100,000 cycles, in which range the phase shift is proportional to frequency, there being a lag of 8° at the upper frequency; also that the ratio of output to input voltages does not vary by more than 5 db. from the 1000-cycle value between 100 kc. and 900 kc. The unit as sent out is ready for operation. It weighs 18 lbs. and is regularly contained in an aluminum case 13″ wide x 9″ x 9″ with carrying strap, but can also be supplied for relay rack mounting.

Roll Surface Pyrometer

Illinois Testing Labs.

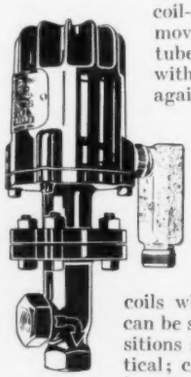
FOR measuring surface temperature of revolving cylinders, this new self-contained thermoelectric pyrometer has a ribbon type thermocouple held in a resilient bow-shaped assembly mounted at one end of a supporting arm of any desired length up to 48″. A grooved carbon block attached to the bow limits the tension on the thermocouple ribbon, so that no matter how much pressure the operator exerts in applying the assembly to the surface of a roll, the ribbon will not be unduly stressed. The bow assembly can be clamped in any desired position, to reach hard-to-get-at surfaces. The millivoltmeter has a 3½″ scale which may be graduated 0-600, 0-800 or 0-1000° F. Internal cold-junction compensation is optionally available.

◆ ◆ ◆

Magnetic Valves

Frick Co., Inc.

ESPECIALLY designed for refrigeration work, these new valves are finding other industrial applications by reason of unique features. Opening and closing is by means of a coil-operated plunger moving inside a gas-tight tube. All valves close with pressure, not against, so that closure is tight. The three largest sizes are so arranged that, while opening, pressure is relieved by an auxiliary port. Fins cast in cover dissipate slight heat evolved in coils when energized. Cover can be set in any of four positions so that it stands vertical; condulet likewise may be set at any desired angle. Angle styles are ½″; globe styles are ½″ to 2½″. Coils furnished for 110 or 220 volts, 25-, 50- or 60-cycle a.c., also 32, 115 or 230 volts d.c.



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Pocket Illumination Meter

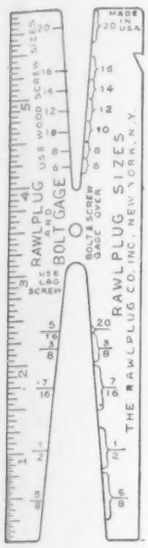
The Sight Light Corp.

WEIGHING but 8 oz. and smaller than the usual engineer's pocket note book, the "Sight Meter" comprises a Weston Photronic cell and a microammeter scaled in foot-candles up to 50 with supplementary notations, "Inadequate . . . Reading Fine Print . . ." etc., for housewives, teachers and non-technical users in general.

Screw and Bolt Gage

The Rawlplug Co., Inc.

TO allow the quick selection of the proper "Rawlplug" for any given wood screw or lag screw, the makers have developed something new in the form of a pocket gage. Upon inserting a wood or lag screw between its jaws, it will show what size "Rawlplug" should be used, and vice versa. One face shows all standard wood and lag screw sizes and gives the corresponding sizes of "Rawlplugs" to be used with each; the other shows all standard "Rawlplug" sizes and corresponding screw sizes to be used with each. Calibrated in fractions of an inch to determine bolt sizes from 3/16" to ¾", it can also be used as a caliper on corresponding sizes of round bars. One edge forms a 6" rule, the other forms a 5" rule slotted for measuring countersunk head screws.

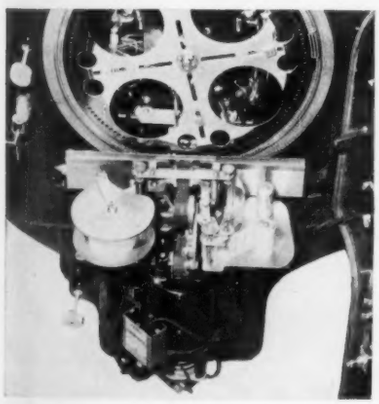


◆ ◆ ◆

Weight Recorder

Toledo Scale Co.

DESIGNED for weighing operations where high production speed must be combined with accuracy, the new Toledo Printweigh, Figured Type, automatically selects the correct weight figure and prints it at the touch of a button in 1/10 second on an inserted ticket, a continuous strip, or both. Button control may be located on the scale



or at a remote point; automatic operation may be had in connection with any type of conveyor system. The Figured Type Printing Device can be furnished on Toledo dial scales of 62½ to 10,000 lbs. capacity, or it can be attached to any late model Toledo dial scale of similar capacity. If desired, it can be supplied with unit weights, which arrangement extends the capacity of the scale.

Fig. 1

Fig. 2

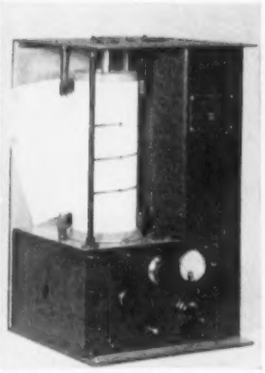


Fig. 3

Internal-combustion Engine Direct-pressure Indicators

Commercial Engineering Labs.

SMALL pressure sampling valves, easily installed (some interchangeable with spark plugs when no other openings can be used) are a feature of the new models of "Research" Indicators —all of which are drum-chart recorders. They are operated once per cycle by electromagnets, the operating impulse being timed by a circuit breaker driven from the crank-shaft or cam-shaft. The valve seats of these pressure sampling elements are flush with the walls, so that there are no disturbing effects such as occur when there is a tube between a combustion chamber (or other enclosed space) and a sampling valve. The instrument, therefore, may be located at a distance from the sampling valves on the engine, without affecting the accuracy of the records. A phase gearing is used to change slowly the timing of the sampling valve, thereby producing a complete diagram or any portion thereof. Pressure-time diagrams are most commonly used, but pressure-volume diagrams can be drawn when the instrument is fitted with a special "P-V" attachment. The new "Type I" (Fig. 1), said to be the most accurate form of single card indicator, produces diagrams on cards 12" long, with the 2" card height representing any required pressure, from 2 to 1250 lbs./in.^{2} There are three other types, all multiple-record, two of which are shown in Figs. 2 and 3, whereby composite cards may be obtained from as many as sixteen cylinders or other points such as intake, supercharger, etc.

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INSTRUMENTS ABSTRACTS

MEASUREMENT TECHNOLOGY (1)

Calculation (1.3)

Electrical Computing; Continuous Addition and Substraction. (Elektrische Rechenoperationen, Stetige Addition und Subtraktion.) JOSEPH KROENERT. *Archiv für Technisches Messen,* Vol. 1, March 30, 1932, section J0821-1, page T23.

The theoretical principle of continuous indication or recording of a process going on in several variable components which have to be added or subtracted is explained. This can be done by the summation of ohmic resistances in series connected to a constant voltage or by the Wheatstone bridge. These methods are described in detail. Ha (1.3)

The Practical Application of the Reynolds Number. (Die praktische Anwendung der Reynold'schen Zahl.) A. KÖVESY. *Die Röhrenindustrie,* Vol. 24, March 26, 1931, pages 73-76; April 9, 1931, pages 88-89.

Some 28 formulae are derived covering the friction losses of water flowing in pipes. The pressure losses at different temperatures and for different liquids and gases are considered and some calculations given as example. EF (1.3)

Graphical and Mechanical Evaluation of Debye-Scherrer Photograms of Cubic, Tetragonal, Hexagonal or Orthorhombic Symmetry, Including the Following Examples: WC, PdF_2 and $HgCl_2$. (Graphische bezw. maschinelle Auswertung von Debye-Scherrer Diagrammen kubischer, tetragonaler, hexagonaler und rhombischer Symmetrie mit Anwendungsbeispielen: WC, PdF_2 und $HgCl_2$.) F. EBERT. *Zeitschrift fuer Kristallographie,* Vol. 78, July 1931, pages 489-495.

A simple evaluation method of Debye-Scherrer photograms is mathematically derived which, in contrast with the Hull-Davey charts, permits the use of straight lines. The possibility of a mechanical evaluation of Debye-Scherrer photograms is indicated and the description of the completed apparatus is announced. The application of the graphical evaluation is demonstrated in the case of the following representative compounds: WC (hexagonal), PdF_2 (tetragonal) and $HgCl_2$ (ortho-rhombic). 6 figs. EF (1.3)

On the Determination of the Explosive Limits of Industrial Gases. (Über die rechnerische Ermittlung der Explosionsgrenzen von Industriegasen.) F. KOFLER. *Gas und Wasserfach,* Vol. 75, April 16, 1932, pages 297-299.

The explosive limits of gas-air mixtures can be calculated with consideration of the inert components according to the formula by Le Châtelier which has been improved by Jones (*Bureau of Mines Bulletin* 279, 1928). For a number of gases the explosive limits have been calculated according to the Jones formula. The results are in accord with experimental determinations. The easy and rapid determination thus possible proves of great advantage to gas and metallurgical plants. 4 references. GN (1.3)

MEASUREMENT & CONTROL (2)

Length, Angle & Area (2.01)

Comparator for Dilatometric Measurements of Ceramic and Refractory Materials. (Komparator fuer dilatometrische Messungen keramische und feuerfester Baustoffe.) *Feuerfest-Ofenbau,* Vol. 7, Nov. 1931, page 169.

E. Leitz Co. comparator. Sensitivity of 0.0005 mm. Optical apparatus briefly described and illustrated. EF (2.01)

Novel Integraph of the Askania Works. (Ueber einen neuen Integraphen der Askania Werke.) J. PICHT, *Zeitschrift fuer angewandte Mathematik und Mechanik,* Vol. 11, Dec. 1931, pages 442-443.

Differento Integraph according to von Harbou and Integraph of Schweydar are touched upon. Universal integraph, designated as "integrometer," is discussed at length and 6 different integration operations, for which the instrument is constructed, are given. Accuracy expected, 1 to 2%. EF (2.01)

Measurement of the Curvature Radii of Edges. (Messung von Schneidenkrummungaradien.) G. SCHMERWITZ, *Zeitschrift für Instrumentenkunde,* Vol. 52, Jan. 1932, pages 1-14.

Describes new mechanical measuring method for determining the curvature radii of edges, developed by the Reichsanstalt fur Erdbebenforschung at Jena, Germany. Extensive investigation of problem led to the establishment of new facts on the curvature of edges. Discusses previous investigations. Reports experiments on razor blades, used pendulum edges, glass capillaries, etc. Comparison of practical results with theoretical conceptions. 6 references. GN (2.01)

The Measuring of Keyways. (Das Messen von Keilnuten.) W. HÄBERLI & F. STREIFF. *Schweizerische Technische Zeitschrift,* Vol. 29, Jan. 7, 1932, pages 11-15.

Largest part of paper is given to description of instruments for checking key and keyway dimensions. GN (2.01)

Optical and Mechanical Measurements and Tools. (Optische und feinmechanische Werkstattmessverfahren und Werkzeuge.) O. P. VAN STEEWEN, *Schweizerische Technische Zeitschrift,* Vol. 29, Jan. 7, 1932, pages 1-8; Jan. 14, 1932, pages 17-20.

Describes a great variety of machine shop instruments. Discusses automatic elimination of subjective errors, efficiency, accuracy, mechanization and easy reproduction of the measurements, manifold applicability by means of auxiliary equipment. GN (2.01)

Special Slide-Gage for Controlling Wedge Grooves. (Spezialschiebelehre zum Kontrollieren von Keilnutwellen.) J. NYIKOS. *Das Werkzeug,* Vol. 8, May 10, 1932, page 64; Supplement to *Maschinenkonstrukteur- Betriebstechnik,* Vol. 65, May 10, 1932.

Describes special slide-gage for controlling improperly milled wedge grooves. Measuring accuracy 0.004". GN (2.01)

On the Accuracy of Construction and the Effect of a Heat Distribution in Some Optical Parts of Telemeters. (Über die Genauigkeit der Bearbeitung und über die Wirkung einer Wärmeverteilung in einigen optischen Teilen der Einstand-Entfernungsmesser.) V. RONCHI & G. B. PACELLA. *Zeitschrift für Instrumentenkunde,* Vol. 52, Feb. 1932, pages 66-70.

The greatest accuracy is required in order to attain a deviation of not more than 0.5 circular seconds in measuring the parallax. Uniform temperature is of extreme importance of all optical parts. 3 references. GN (2.01)

A New Micrometer. (Ein neues Mikrometer.) F. KRAUTSCHNEIDER. *Zeitschrift für Instrumentenkunde,* Vol. 52, Feb. 1932, pages 74-77.

Screw micrometers all possess the disadvantage of being subjected to wear. An optical method has been devised which mathematical discussion of the principle employed shows to be practically errorless. New micrometer, "Heydeische Feinablesung," is built by G. Heyde, Dresden. GN (2.01)

Leveling Instrument According to A. Fennel. (Fein- Nivellierinstrument von A. Fennel.) E. WERKMEISTER, *Zeitschrift für Instrumentenkunde,* Vol. 52, Feb. 1932, pages 89-91.

The leveling instrument described has been built for most accurate measurements. GN (2.01)

Measurement of Curvature Radii by Means of Auto Collimation. (Messung von Krümmungsradien durch Autokollimation.) FÜGGE. *Zeitschrift für Instrumentenkunde,* Vol. 52, Feb. 1932, page 94.

Abstract of a paper by A. Arnulf in *Revue d' Optique,* Vol. 10, 1931, pages 22-43; 69-92, which deals with the methods of measuring curvative radii by autocollimation. Advantages and disadvantages of each of these methods are discussed. The author developed a new method. In the second part of the paper the various measuring instruments are described. GN (2.01)

Indicating Caliper. FARREL-BIRMINGHAM CO., INC. *Instruments,* Vol. 5, August 1932, page 197.

New instrument designed for gaging large rolls, reads to 0.0001 in. by dial gage, insures desired crown. 1 fig. MFB (2.01)

Distance Measurements with Double Image Tachymeters in Mines. (Längenmessungen mit Doppelbildtachymetern in der Grube.) TH. EVERSMANN. *Zeitschrift für Instrumentenkunde,* Vol. 52, Feb. 1932, pages 53-65.

The mean errors of various double image tachymeters used in experiments for measuring distances in mines show that they can be used for checking results of mine surveys. A shortcoming of the double image tachymeter is its bulky construction. Most adaptable to this purpose are the Bosshardt-Zeiss reduction tachymeter and the Aregger-Hildebrand double image tachymeter. 8 references. GN (2.01)

A Method for the Measurement of Extremely Small Rotation Angles. (Eine Methode zur Messung von äusserst kleinen Rotationswinkeln.) G. BIRADREI, *Zeitschrift für Instrumentenkunde,* Vol. 52, May, 1932, pages 234-235.

Poggendorf method cannot be applied to the measurement of extremely small angles and Marcel Brillouin method (*Comtes Rendus,* Vol. 133, 1903, page 786) for increasing the measuring accuracy of small angular rotations can be used only in special cases. Author developed and describes a new method (to be used only for rotations around the horizontal axis) in which an accuracy of better than 0.01 seconds is attained. GN (2.01)

Decreasing the Stock on Gages by Adjustable Gages. (Verringerung des Lehrenbestandes durch verstellbare Lehren.) *Emmailletechnische Monatsblätter,* June 1932, pages 44-45.

Efficiency effected by adjustable gages. GN (2.01)

On New Integraphers of the Askania Works. (Über neue Integraphen der Askania Werke A.G.) JOHANNES PICHT. *Zeitschrift für Instrumentenkunde,* Vol. 52, July 1932, pages 289-299.

Discusses "Differento integrapher" of von Harbou; prism derivator by the same inventor; integrating apparatus according to Schweydar; an apparatus for evaluating the curve integer; the "Integrometer" also to be used for integrating certain functions. The evaluation of double and triple integrations is also discussed and exemplified. GN (2.01)

The Ordovás-Kern Photo-Cartographer. (Photo-Kartograph, Ordovás-Kern.) P. WERKMEISTER. *Zeitschrift für Instrumentenkunde,* Vol. 52, March 1932, pages 142-143.

Air map measuring instrument developed by the Spanish engineer Ordovas and built by the Kern Company at Aarau, Switzerland. GN (2.01)

Four New Cartographic Instruments. (Vier neue Kartierungsinstrumente der Firma A. Ott in Kempten.) P. WERKMEISTER. *Zeitschrift für Instrumentenkunde,* Vol. 52, April 1932, pages 195-198.

(1) a "Kordionatograph," for plotting points in rectangular coordinates with a range of 67 cm. for the abscissae and 100 cm. for the ordinates, (2) a similar smaller instrument with a range of 25 cm. for the abscissae and 12.5 cm. for the ordinates, and 2 cartographic rules. GN (2.01)

Pressure & Vacuum (2.04)

The Paulin Aneroid Barometer. (Metallbarometer System Paulin.) P. WERKMEISTER. *Zeitschrift fuer Instrumentenkunde,* Vol. 51, Aug. 1931, pages 435-438.

Describes aneroid barometer invented by the Swedish engineer Paulin, employing "null" principle. EF (2.04)

Experiments on the Pseudo-High-Vacuum. (Versuche ueber das Pseudohochvakuum.) E. BADAREU. *Zeitschrift fuer technische Physik,* Vol. 12, May 1931, pages 299-303.

The wall charge phenomenon is discussed and considered of being responsible for the source of error in the measurements in discharge tubes of low pressure. EF (2.04)

Recording Gas Pressure Meter for Rifles. (Registrierender Gasdruckmesser fuer Gewehre.) H. RUMPFF. *Zeitschrift fuer das gesamte Schiess- & Sprengstoffwesen,* Vol. 26, Jan. 1931, pages 10-13.

Explosion time is a fraction of 1/1000 sec. and pressures amount to 1500-3500 atm. The L.P.G.P. String Instrument includes steel leaf spring on which a mirror is rigidly attached, and a rapidly rotating film drum. The instrument can record 16,000 oscillations per sec. EF (2.04)

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Volume X NOVEMBER, 1933 Number 11

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Defender Autom'c Reg. Co.
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Taylor Instrument Cos.

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Bristol Company
Brown Instrument Co.
Defender Autom'c Reg. Co.
Foxboro Co.
Morey & Jones, Ltd.
Pioneer Instrument Co.
Taylor Instrument Cos.

Demand Pressure
Bailey Meter Co.
Foxboro Co.
Pioneer Instrument Co.

Feed Water
American Meter Co.
Bailey Meter Co.
Bristol Co.
Brown Instrument Co.
Foxboro Co.

Filter Rate
Bristol Company
Brown Instrument Co.
Foxboro Co.

Flow
American Meter Co.
Bailey Meter Co.
Brown Instrument Co.
Foxboro Co.
Pioneer Instrument Co.

Gravity
Bailey Meter Co.

Humidity
Bristol Company
Brown Instrument Co.
Foxboro Co.
Taylor Instrument Cos.

Humidity & Temperature
Bristol Company
Brown Instrument Co.
Foxboro Co.
Taylor Instrument Cos.

Liquid Level
American Meter Co.
Bailey Meter Co.
Bristol Company
Brown Instrument Co.
Foxboro Co.
Pioneer Instrument Co.

Materials Testing, Strain-Time
Baldwin-Southwark Corp.

Materials Testing, Stress-Time
Baldwin-Southwark Corp.

Materials Testing, Load Maintenance
Baldwin-Southwark Corp.

Pressure & Vacuum
American Meter Co.
Bailey Meter Co.
Bristol Company
Brown Instrument Co.
Foxboro Co.
Pioneer Instrument Co.
Taylor Instrument Cos.

Pyrometer
Bailey Meter Co.
Bristol Company
Brown Instrument Co.
Defender Autom'c Reg. Co.
Foxboro Co.
Taylor Instrument Cos.

Rate-Volume
American Meter Co.
Foxboro Co.

Refrigeration
Bristol Company
Brown Instrument Co.
Taylor Instrument Cos.

Tachometer
Bailey Meter Co.
Bristol Company
Brown Instrument Co.
Foxboro Co.
Pioneer Instrument Co.
Weston Elec. Inst. Corp.

Temperature-Time
Bristol Company
Brown Instrument Co.
Foxboro Co.
Pioneer Instrument Co.
Taylor Instrument Cos.

Thermometer
Bailey Meter Co.
Bristol Company
Brown Instrument Co.
Defender Autom'c Reg. Co.
Foxboro Co.
Taylor Instrument Cos.

Thermostat
Bristol Company
Brown Instrument Co.
Foxboro Co.
Pioneer Instrument Co.
Taylor Instrument Cos.

Time
Bristol Company
Brown Instrument Co.
Foxboro Co.
Taylor Instrument Cos.

Vacuum
Bailey Meter Co.
Bristol Company
Brown Instrument Co.
Foxboro Co.
Taylor Instrument Cos.

Valve—Motor Operated
Bristol Company
Brown Instrument Co.
Foxboro Co.
Taylor Instrument Cos.

Voltage A.C.

Water Level
American Meter Co.
Bailey Meter Co.
Bristol Company
Brown Instrument Co.
Foxboro Co.
Pioneer Instrument Co.
Taylor Instrument Cos.

COUNTERS—Ratchet, Magnetic
Esterline-Angus Co.

Revolution
Baldwin-Southwark Corp.
Bristol Company
Brown Instrument Co.
Pioneer Instrument Co.

Stroke
Baldwin-Southwark Corp.
Bristol Company

CREEP TESTER
Baldwin-Southwark Corp.

CUBIC FOOT BOTTLES
American Meter Co.

CURRENT RECORDERS
Bristol Company
General Electric Co.
Esterline-Angus Co.

CYCLE CONTROLLERS
Bristol Co.

CYCLE COUNTERS
General Radio Co.

CYCLOMETERS

DAMPING TESTER
Baldwin-Southwark Corp.

DEFORMETER (Beggs)
Baldwin-Southwark Corp.

DEMAND METERS
Gas
Foxboro Co.

Electric: Indicating, Recording, Printing
General Electric Co.

DIVIDING HEAD
Optical

DIVIDING MACHINES
Gaertner Scientific Corp.

DRAFT GAGES—See Gages

DYNAMOMETERS
General Electric Co.
Rawson Elec. Inst. Co.
Weston Elec. Inst. Corp.

EARTH CURRENT METERS
Rawson Elec. Inst. Co.

ELECTRIC TELEMETERS
Baldwin-Southwark Corp.
Esterline-Angus Co.
General Electric Co.
Pioneer Instrument Co.

ELECTRIC WAVE FILTER SECTIONS
General Radio Company

ELECTROMETERS

ELECTRONIC METERS
Esterline-Angus Co.
General Electric Co.
General Radio Co.
Rawson Elec. Inst. Co.

ENGINE INDICATORS
Baldwin-Southwark Corp.

ENGINE REVOLUTION COUNTERS

EXTENSOMETER
Baldwin-Southwark Corp.

FATIGUE TESTERS
Baldwin-Southwark Corp.

FAULT FINDERS
Weston Elec. Inst. Corp.

FIELD RHEOSTATS

FLASH & BURNING POINT TESTERS
Taylor Instrument Cos.

FLOW METERS
Indicating
Bailey Meter Co.
Brown Instrument Co.
Defender Autom'c Reg. Co.
Morey & Jones, Ltd.
Pioneer Instrument Co.

Indicating & Recording
American Meter Co.
Bailey Meter Co.
Brown Instrument Co.
Foxboro Co.
Pioneer Instrument Co.

Integrating & Recording
American Meter Co.
Morey & Jones, Ltd.

FLUE GAS ANALYZERS
Brown Instrument Co.

FLUXMETERS
Rawson Elec. Inst. Co.

FREQUENCY METERS
Indicating
General Electric Co.
Weston Elec. Inst. Corp.

Recording
Bristol Company
Esterline-Angus Co.
General Electric Co.

Standards
General Radio Co.

FUEL FLOW INDICATORS
Morey & Jones, Ltd.
Pioneer Instrument Co.

FURNACE CONTROLS
Bailey Meter Co.
Bristol Company
Defender Autom'c Reg. Co.
Taylor Instrument Cos.

GAGES
Absolute Pressure
American Meter Co.
Bristol Company
Brown Instrument Co.
Foxboro Co.
Taylor Instrument Cos.

Amplifying

Comparator

Cylinder

Deformation
Baldwin-Southwark Corp.

Dial

Differential Pressure
Bailey Meter Co.
Brown Instrument Co.
Foxboro Co.
Morey & Jones, Ltd.
Pioneer Instrument Co.

Draft
Taylor Instrument Cos.
Bailey Meter Co.
Bristol Company
Brown Instrument Co.
Foxboro Co.
Taylor Instrument Cos.

Drill
Bausch & Lomb Optical Co.

Filter Rate
Morey & Jones, Ltd.

Flow
American Meter Co.
Bailey Meter Co.
Brown Instrument Co.
Morey & Jones, Ltd.

Liquid Level
American Meter Co.
Bailey Meter Co.
Bristol Company
Brown Instrument Co.
Esterline-Angus Co.
Foxboro Co.
Morey & Jones, Ltd.
Pioneer Instrument Co.
Taylor Instrument Cos.

Loss of Head
Bailey Meter Co.
Bristol Company
Brown Instrument Co.
Foxboro Co.
Morey & Jones, Ltd.

Pitch Diameter

Pressure
American Meter Co.
Bailey Meter Co.
Baldwin Southwark Corp.
Bristol Company
Brown Instrument Co.
Esterline-Angus Co.
Foxboro Co.
Taylor Instrument Cos.

Pressure-Temperature
Bailey Meter Co.
Bristol Company
Brown Instrument Co.
Esterline-Angus Co.
Foxboro Co.
Taylor Instrument Cos.

Pressure & Vacuum
Bailey Meter Co.
Bristol Company
Brown Instrument Co.
Esterline-Angus Co.
Foxboro Co.
Taylor Instrument Cos.

Profile

Rain
Esterline-Angus Co.
Taylor Instrument Cos.

Recording—Distance
Bailey Meter Co.
Bristol Company
Brown Instrument Co.
Esterline-Angus Co.
Pioneer Instrument Co.
Taylor Instrument Cos.

Strain
Baldwin-Southwark Corp.
General Electric Co.

Tester
Baldwin-Southwark Corp.

Thickness
Esterline-Angus Co.

Vacuum
Esterline-Angus Co.
General Electric Co.
Taylor Instrument Cos.

Volume
American Meter Co.
Brown Instrument Co.
Foxboro Co.

Water Level for Boilers
American Meter Co.
Bailey Meter Co.
Bristol Company
Brown Instrument Co.
Foxboro Co.
Pioneer Instrument Co.

Wind
Bristol Company
Brown Instrument Co.
Esterline-Angus Co.

GALVANOMETERS
American Meter Co.
Brown Instrument Co.
General Radio Co.
Rawson Elec. Inst. Co.
Taylor Instrument Cos.
Weston Elec. Inst. Corp.

GAS ANALYTICAL METERS
Electrical
Brown Instrument Co.

GAS FLOW INDICATORS
American Meter Co.
Morey & Jones, Ltd.

GAS LEAK INDICATORS
Taylor Instrument Cos.

GAS-METERS
American Meter Co.
Bailey Meter Co.
Brown Instrument Co.
Foxboro Co.

Dry Test
American Meter Co.

Wet Test
American Meter Co.

GOVERNORS
Pressure
Bailey Meter Co.
Bristol Company
Brown Instrument Co.
Taylor Instrument Cos.

Pump
Bailey Meter Co.
Taylor Instrument Cos.

Water Wheel
Baldwin-Southwark Corp.

GRAVITOMETERS
American Meter Co.

GROUND DETECTORS
Weston Elec. Inst. Corp.

HAND TALLEYS

HARDNESS TESTERS
Baldwin-Southwark Corp.

HELIOSTATS
Gaertner Scientific Corp.

HIGH FREQUENCY APPARATUS
Rawson Elec. Inst. Co.
Weston Elec. Inst. Corp.

HIGH VOLTAGE Indicators
Weston Elec. Inst. Corp.

Measuring Devices
General Electric Co.
Weston Elec. Inst. Corp.

Testing Devices
General Electric Co.

HUB ODOMETERS

HUMIDITY CONTROLLERS
Bristol Company
Brown Instrument Co.
Foxboro Co.
Taylor Instrument Cos.

HUMIDITY RECORDERS
Wet & Dry Bulb Thermometers
Bristol Company
Brown Instrument Co.
Foxboro Co.
Taylor Instrument Cos.

HYDROGEN ION METERS

HYDROMETERS
Taylor Instrument Cos.

HYGROMETERS
Brown Instrument Co.
Foxboro Co.
Taylor Instrument Cos.

ILLUMINOMETERS
Weston Elec. Inst. Co.

INDICATORS—See Gages

INDUCTANCES
General Radio Co.

INSTRUMENT CALIBRATION AND REPAIRS
Esterline-Angus Co.
Rawson Elec. Inst. Co.
Weston Elec. Inst. Corp.

INSTRUMENT TRANSFORMERS
Esterline-Angus Co.
General Electric Co.
Weston Elec. Inst. Corp.

Split Core

Phase Shifting

INSULATION TESTING EQUIPMENT
General Electric Co.

INTERFEROMETERS
Gaertner Scientific Corp.

KEYS AND SWITCHES
General Radio Co.

LABORATORY RHEOSTATS

LACTOMETERS
Taylor Instrument Cos.

LENGTH MEASURING MACHINES
Gaertner Scientific Corp.

LEVELS
Centering

Engineer's, Wye, Precision

Prism
Taylor Instrument Cos.

LOCOMOTIVE INDICATORS
Baldwin-Southwark Corp.

MAGNETIC RELAYS

MAGNETOMETERS

MANOMETERS
Bailey Meter Co.
Bristol Co.
Brown Instrument Co.
Defender Autom'c Reg. Co.
Foxboro Co.
Morey & Jones, Ltd.

MASTER CLOCKS
Gaertner Scientific Corp.
General Electric Co.

MEGOHMMETERS

MEGOHM VOLTMETERS
Weston Elec. Inst. Corp.

MICROAMMETERS
Esterline-Angus Co.
General Electric Co.
General Radio Co.
Rawson Elec. Instru. Co.
Weston Elec. Inst. Corp.

MICROFARADMETERS
General Radio Co.
Weston Elec. Inst. Corp.

MICROMETERS
Gaertner Scientific Corp.

MICROMETER SLIDES
Gaertner Scientific Corp.

MICROSCOPES
Brinell
Gaertner Scientific Corp.

Measuring
Gaertner Scientific Corp.

Metallographic

Petrographical

Toolmakers'
Gaertner Scientific Corp.

MICROTOMES

MILLIAMMETERS
Bristol Company
Esterline-Angus Co.
General Electric Co.
General Radio Co.
Rawson Elec. Inst. Co.
Weston Elec. Inst. Corp.

MILLIVOLTMETERS
Bristol Company
Brown Instrument Co.
General Electric Co.
Esterline-Angus Co.
Rawson Elec. Inst. Co.
Taylor Instrument Cos.
Weston Elec. Inst. Corp.

MIRRORS

MODULATION METERS
Esterline-Angus Co.
General Radio Co.
Weston Elec. Inst. Corp.

MOISTURE METERS
General Radio Co.

MOTION RECORDERS
Mechanical
Baldwin-Southwark Corp.
Bristol Company
Esterline-Angus Co.
Foxboro Co.

MOTOR STARTERS

MULTIMETERS
Rawson Elec. Inst. Co.

MULTIPLE PEN RECORDERS
Baldwin-Southwark Corp.
Bristol Co.
Esterline-Angus Co.
Foxboro Co.

MULTIPLIERS
General Electric Co.
Weston Elec. Inst. Corp.

NICKEL SOLUTION TESTERS

NOISE MEASURING SETS
Burgess Labs., Inc., C. F.
General Radio Co.

OHM METERS
Esterline-Angus Co.
General Electric Co.
Rawson Elec. Inst. Co.
Weston Elec. Inst. Corp.

OIL TESTING APPARATUS
General Electric Co.
Taylor Instrument Cos.

OPERATION RECORDERS
Electrical
Bristol Company
Brown Instrument Co.
Esterline-Angus Co.
Foxboro Co.
Taylor Instrument Cos.

OPTICAL PARTS
Lenses, Prisms, Test Planes
Gaertner Scientific Corp.

ORIFICE METERS
Indicating & Recording
American Meter Co.
Bailey Meter Co.
Brown Instrument Co.
Defender Autom'c Reg. Co.
Foxboro Co.
Morey & Jones, Ltd.

Integrating
American Meter Co.

OSCILLATORS
Weston Elec. Inst. Corp.

OSCILLOGRAPHS
Baldwin-Southwark Corp.
General Electric Co.
General Radio Co.

Automatic
General Electric Co.

Cathode Ray
General Electric Co.

PANTOGRAPHS
Gaertner Scientific Corp.

PERISCOPES
Gaertner Scientific Corp.

PERMEAMETERS
General Electric Co.

PHOTO-ELECTRIC CELLS
General Electric Co.
Weston Elec. Inst. Corp.

PHOTO-ELECTRIC COLOR ANALYZERS
General Electric Co.
PHOTO-ELECTRIC COLOR COMPARATORS
General Electric Co.
PHOTOMETERS
Gaertner Scientific Corp.
PHOTO-MICROGRAPHIC EQUIPMENT
Rawson Elec. Instru. Co.
PHYSICAL TESTING MACHINES
Baldwin-Southwark Corp.
PITOT TUBE METERS
Brown Instrument Co.
Defender Autom'c Reg. Co.
Foxboro Co.
Morey & Jones, Ltd.
Pioneer Instrument Co.
PLANIMETERS
Automatic Flow Record
Brown Instrument Co.
Foxboro Co.
Linear
Brown Instrument Co.
Baldwin-Southwark Corp.
Radial
Bailey Meter Co.
Bristol Company
Foxboro Co.
Square Root
Foxboro Co.
POLARISCOPES
Gaertner Scientific Corp.
POSITION RECORDERS
Brown Instrument Co.
Bristol Company
Esterline-Angus Co.
Foxboro Co.
Taylor Instrument Cos.
POTENTIOMETERS—
Indicating
Brown Instrument Co.
General Electric Co.
Recording & Controlling
Brown Instrument Co.
Standard Cell Comparing
Feussner Type
POWER FACTOR METERS
Esterline-Angus Co.
General Electric Co.
Weston Elec. Inst. Corp.
PRESSURE RECORDERS
American Meter Co.
Bailey Meter Co.
Baldwin-Southwark Corp.
Bristol Company
Brown Instrument Co.
Defender Autom'c Reg. Co.
Esterline-Angus Co.
Foxboro Co.
Taylor Instrument Cos.
PRISMS
Gaertner Scientific Corp.
PROCESS TIMING & SIGNALING INSTRUMENTS
Bristol Company
Brown Instrument Co.
Esterline-Angus Co.
Foxboro Co.
Taylor Instrument Cos.
PROTRACTOR
Optical
PROVERS
American Meter Co.
PSYCHROMETERS
Recording
Bristol Company
Brown Instrument Co.
Foxboro Co.
Taylor Instrument Cos.
Sling
Taylor Instrument Cos.
PYRHELIOMETERS—
Weather Bureau Type
PYROMETERS
Optical
Radiation
Indicating
Brown Instrument Co.
Taylor Instrument Cos.
Recording
Brown Instrument Co.
Taylor Instrument Cos.
Thermo-electric
Immersion
Bristol Company
Brown Instrument Co.
Foxboro Co.
Taylor Instrument Cos.
Indicating
Bristol Company
Brown Instrument Co.
Defender Autom'c Reg. Co.
Foxboro Co.
Taylor Instrument Cos.
Recording and Controlling
Bristol Company
Brown Instrument Co.
Foxboro Co.
Taylor Instrument Cos.
Surface Contact
Bristol Company
Brown Instrument Co.
Taylor Instrument Cos.
RADIO FREQUENCY OSCILLATORS
General Radio Company
RADIO SET ANALYZERS
Weston Elec. Inst. Corp.
RADIO TEST PANEL
Weston Elec. Inst. Corp.
RADIO TUBE CHECKERS
General Radio Company
Weston Elec. Inst. Corp.
REFRACTOMETERS
REGULATORS—See Controls

RELAYS
General Electric Co.
General Radio Co.
Weston Elec. Inst. Corp.
Light Sensitive
Burgess Labs., Inc., C. F.
Weston Elec. Inst. Corp.
Vacuum Contact
Burgess Labs., Inc., C. F.
Vacuum Tube
Burgess Labs., Inc., C. F.
REMOTE METERING EQUIPMENT
American Meter Co.
Bailey Meter Co.
Bristol Company
Brown Instrument Co.
Esterline-Angus Co.
General Electric Co.
Morey & Jones, Ltd.
Pioneer Instrument Co.
RESISTANCE—Electrical
General Radio Co.
RESISTANCE COILS
RESISTOR UNITS
RHEOSTATS
General Radio Company
SACCHARIMETERS
Taylor Instrument Cos.
SALINITY INDICATORS
Esterline-Angus Co.
SCALES
Gaertner Scientific Corp.
SEISMOGRAPHS
SELSYN EQUIPMENT
General Electric Co.
SHUNT METERS
Bristol Company
Esterline-Angus Co.
SHUNTS
Esterline-Angus Co.
General Electric Co.
Rawson Elec. Inst. Co.
Weston Elec. Inst. Corp.
SIGNALING DEVICES—Automatic
Bristol Co.
Brown Instrument Co.
Foxboro Co.
Pioneer Instrument Co.
SPECIAL COILS
SPECIAL ELECTRICAL INSTRUMENTS
Bristol Company
Brown Instrument Co.
Esterline-Angus Co.
General Electric Co.
General Radio Co.
Morey & Jones, Ltd.
Pioneer Instrument Co.
Rawson Elec. Inst. Co.
Weston Elec. Inst. Corp.
SPECIAL INSTRUMENTS
Esterline-Angus Co.
SPECTROGRAPHS
Gaertner Scientific Corp.
SPECTROMETERS
Gaertner Scientific Corp.
SPECTROPHOTOMETERS
Gaertner Scientific Corp.
SPECTROSCOPES
Gaertner Scientific Corp.
SPEED COUNTERS
SPEED INDICATORS
See Tachometers
SPEED RECORDERS
Bristol Company
Brown Instrument Co.
Esterline-Angus Co.
SPEED REGULATORS
STANDARD CELLS
Weston Elec. Inst. Corp.
STOP WATCHES
STRAIN GAGES
Baldwin-Southwark Corp.
General Electric Co.
SUNSHINE RECORDERS
Taylor Instrument Cos.
SURGE INDICATORS & RECORDERS
Esterline-Angus Co.
General Electric Co.
SYNCHRONOSCOPES
Weston Elec. Inst. Corp.
SYNCHRONIZATION FORKS
Electrical
General Radio Co.
SYNCHRONOUS MOTORS
General Electric Co.
Pioneer Instrument Co.
TACHOGRAPH
Baldwin-Southwark Corp.
TACHOMETERS
Bailey Meter Co.
Bristol Company
Brown Instrument Co.
Esterline-Angus Co.
Foxboro Co.
Pioneer Instrument Co.
Weston Elec. Inst. Corp.
TACHOSCOPES
Brown Instrument Co.
TELEMETERS
Baldwin-Southwark Corp.
Esterline-Angus Co.
Pioneer Instrument Co.
TELESCOPES
Gaertner Scientific Corp.
TENSOMETER (Huggenberger)
Baldwin-Southwark Corp.

TESTING MACHINES
Fatigue
Baldwin-Southwark Corp.
Impact
Baldwin-Southwark Corp.
Hardness
Baldwin-Southwark Corp.
Portable—Tensile—Compression
Baldwin-Southwark Corp.
Sheet Metal
Baldwin-Southwark Corp.
Oil & Bearing
Baldwin-Southwark Corp.
Universal
Baldwin-Southwark Corp.
THERMIONIC RECTIFIERS
General Electric Co.
THERMO-JUNCTIONS (Electric)
General Radio Co.
Rawson Elec. Inst. Co.
THERMO-VOLTMETERS & AMMETERS
General Radio Company
Rawson Elec. Inst. Co.
Weston Elec. Inst. Corp.
THERMOPILE—Coblentz Type
THERMOMETERS
Bailey Meter Co.
Bristol Company
Brown Instrument Co.
Gas Filled
Defender Autom'c Reg. Co.
Foxboro Co.
Taylor Inst. Companies
Mechanical
Brown Instrument Co.
Defender Autom'c Reg. Co.
Foxboro Co.
Mercurial
Bristol Company
Taylor Instrument Cos.
Resistance
Brown Instrument Co.
Foxboro Co.
Vapor-Tension
Bristol Company
Brown Instrument Co.
Defender Autom'c Reg. Co.
Foxboro Co.
Taylor Inst. Companies
Wet & Dry Bulb
Bristol Company
Brown Instrument Co.
Foxboro Co.
Taylor Instrument Cos.
THERMOSTATS
Bristol Company
Brown Instrument Co.
Foxboro Co.
Taylor Instrument Cos.
TIME INDICATORS
Baldwin-Southwark Corp.
TIME METERS
General Electric Co.
TIME OPERATION RECORDERS
Bristol Company
Esterline-Angus Co.
Foxboro Co.
TIME RECORDERS
Bristol Company
Brown Instrument Co.
Esterline-Angus Co.
Gaertner Scientific Corp.
Foxboro Co.
TIME SWITCHES
General Electric Co.
TIMERS
Rawson Elec. Inst. Co.
TIMING DEVICES
General Electric Co.
TORSIOGRAPH
Baldwin-Southwark Corp.
TOTALIZING INSTRUMENTS
American Meter Co.
General Electric Co.
TOTALIZING RELAYS
Electric
General Electric Co.
TRANSFORMATION POINT RECORDERS
Brown Instrument Co.
TRANSFORMERS (Instrument)
Esterline-Angus Co.
General Electric Co.
General Radio Co.
Weston Elec. Inst., Corp.
TRANSITS
Astronomical
Gaertner Scientific Corp.
Pocket
Taylor Instrument Cos.
TUNING FORKS—Electrically Driven
General Electric Co.
General Radio Co.
Gaertner Scientific Corp.
TURBIDITY METERS
U-TUBE MANOMETERS
Bailey Meter Co.
Brown Instrument Co.
Defender Autom'c Reg. Co.
Morey & Jones, Ltd.
Taylor Instrument Cos.

VACUUM RECORDERS
Bailey Meter Co.
Bristol Company
Brown Instrument Co.
Defender Autom'c Reg. Co.
Esterline-Angus Co.
Foxboro Co.
Taylor Instrument Cos.
VACUUM TUBE BRIDGES
General Radio Company
VACUUM TUBE RELAYS
Burgess Labs., Inc., C. F.
VACUUM TUBE VOLTMETERS
General Electric Co.
General Radio Co.
Rawson Elec. Inst. Co.
VALVES
Automatic Shut-Off
Bristol Company
Brown Instrument Co.
Defender Autom'c Reg. Co.
Foxboro Co.
Taylor Instrument Cos.
Back Pressure
American Meter Co.
Balanced
Bailey Meter Co.
Baldwin-Southwark Corp.
Brown Instrument Co.
Defender Autom'c Reg. Co.
Foxboro Co.
Taylor Instrument Cos.
Blow-off
American Meter Co.
Diaphragm
Bristol Company
Defender Autom'c Reg. Co.
Foxboro Co.
Taylor Instrument Cos.
Differential
American Meter Co.
Electrically Operated
Baldwin-Southwark Corp.
Bristol Company
Brown Instrument Co.
General Electric Co.
Taylor Instrument Cos.
Motor Operated
Baldwin-Southwark Corp.
Bristol Co.
Pressure Relief
American Meter Co.
Proportional Air-Gas
American Meter Co.
Reducing
Bailey Meter Co.
Taylor Instrument Cos.
Regulating
American Meter Co.
Bailey Meter Co.
Bristol Co.
Brown Instrument Co.
Defender Autom c Reg. Co.
Foxboro Co.
Taylor Instrument Cos.
VENTURI METERS
Bailey Meter Co.
Brown Instrument Co.
Foxboro Co.
Morey & Jones, Ltd.
Pioneer Instrument Co.
VIBROGRAPH
Baldwin-Southwark Corp.
VIBROSCOPE
Baldwin-Southwark Corp.
VISCOSIMETERS
Taylor Inst. Companies
VOLTAGE DIVIDERS
General Radio Co.
VOLT-AMMETERS
Esterline-Angus Co.
General Electric Co.
Weston Elec. Inst. Corp.

VOLTMETERS
Electrostatic
General Electric Co.
Rawson Elec. Inst. Co.
Indicating
General Electric Co.
General Radio Co.
Rawson Elec. Instru. Co.
Weston Elec. Inst. Corp.
Recording
Bristol Company
Esterline-Angus Co.
General Electric Co.
Thermionic Rectifier
General Radio Co.
WATER METERS
Bailey Meter Co.
Brown Instrument Co.
Foxboro Co.
Morey & Jones, Ltd.
WATTHOUR METERS
General Electric Co.
WATTMETERS
Indicating
General Electric Co.
Rawson Elec. Inst. Co.
Weston Elec. Inst. Corp.
Recording
Bristol Company
Esterline-Angus Co.
General Electric Co.
WAVEMETERS
General Radio Co.
X-RAY SPECTROMETERS
Gaertner Scientific Corp.

What instrument do you want to buy?

If you do not see listed in the Advertising pages or in the INSTRUMENTS INDEX the instruments and devices for measurement, inspection and control you wish to purchase . . .

the Publishers of this Journal

will be pleased to forward your request to the manufacturers of such instruments.

Dr. H. W. Gillett, director of Battelle Memorial Institute, Columbus, Ohio, has announced the establishment at the Institute of a research project sponsored by the Elgin National Watch Co. for the study of the metallurgy of watch-making. Improvement and standardization of the metal in watch parts are the primary aims of this project, on which James L. Gregg and A. W. MacLaren, metallurgists, and Dr. H. W. Russell, chief physicist, will work.

Dr. M. Luckiesh, Director of the General Electric lighting research laboratory at Nela Park, Cleveland, was recently appointed Representative of the U. S. National Committee on the Technical Committee on Ultra-violet Radiation of the International Commission on Illumination.

The purpose of the Committee is to define units and methods of measurement and appraisal of ultra-violet radiation. Dr. Luckiesh's appointment as Representative is in recognition of his pioneering work on artificial sunlight, dual-purpose lighting, and the general application of ultra-violet radiation for the benefit of civilization.

The next meeting of the International Commission on Illumination is scheduled to be held in Germany in 1934.

Directors of the General Electric X-Ray Corp., of Chicago on September 20 named **John H. Clough** president to succeed **C. F. Samms,** who became chairman of the board. Mr. Clough entered the G. E. research laboratory in 1914, and contributed to the development of tungsten contacts, rolled sheath wire, tungar rectifiers, lightning and surge-detecting devices, and various vacuum tube and X-ray tube improvements. After serving 2½ years with the A.E.F., he headed the special products section of the G. E. central station department, and in 1925 was appointed assistant to the president of the G. E. X-Ray Corp. Mr. Samms was the founder, with J. B. Wantz, of the orignal Victor Electric Co. in 1893, and was the active head of his organization through its merger in 1916 with Scheidel-Western, Snook-Roentgen, and McAllister-Wiggin companies. It was merged with G. E. in 1921.

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